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The Relationship Between the Use of U.S. Government Technical Reports by U.S. Aerospace Engineers and Scientists and Selected Institutional and Sociometric Variables

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CHAPTER 1

THE STUDY IN PERSPECTIVE

This study focuses on the transfer and utilization of knowledge resulting from federally funded aerospace research and development (R&D).[1] It is based on three assumptions: (1) that knowledge production, transfer, and utilization are equally important components of the aerospace R&D process, (2) that the diffusion of knowledge resulting from federally funded aerospace R&D is indispensable in maintaining the vitality and international competitiveness of the U.S. aerospace industry, and (3) that the U.S. government technical report plays an important, but as yet undefined, role in the aerospace knowledge diffusion process.

This study has both an immediate and a broader purpose. In the first instance, it provides an empirical basis for understanding the role of the U.S. government technical report in the diffusion of knowledge resulting from federally funded aerospace R&D. In the broader sense, it provides insight regarding the information-seeking habits, practices, needs, and preferences of U.S. aerospace engineers and scientists.

BACKGROUND

"Judged against almost any criterion of performance -- growth in output, exports, productivity, or innovation -- the U.S. aerospace industry, in particular the commercial aviation sector, must be considered a star performer in the American

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[1]This research is supported by the National Aeronautics and Space Administration under Grant NAGW-1682.

economy" (Mowery and Rosenberg, 1982). "Total factor productivity in this [the commercial aviation sector] industry has grown more rapidly than in virtually any other U.S. industry during the postwar period" (Mowery, 1985). In 1989, the U.S. aerospace industry continues to be the leading positive contributor to the balance of trade among all merchandise industries, including agriculture (U.S. Department of Commerce, 1990). Along with this performance record, the U.S. aerospace industry, in particular the commercial aviation sector, presents important anomalies in structure and conduct that make it worthy of investigation from the standpoint of enhancing innovation and productivity and understanding the innovation process. These anomalies include the factors that influence the rate and direction of innovation, the diffusion of federally funded aerospace R&D, and Federal involvement in supporting civilian R&D.

Unique Characteristics

The U.S. aerospace industry exhibits certain characteristics that make it unique among other industries. First, the U.S. aerospace sector leads all other industries in expenditures for R&D. Total R&D expenditures on U.S. aerospace projects reached $24 billion in 1988 (U.S. Department of Commerce, 1990). Second, the U.S. aerospace industry has benefitted as a technological "borrower" from developments in other industries such as metallurgy, materials, chemicals, and petroleum (Mowery and Rosenberg, 1982). Third, the aerospace industry, in particular the commercial aviation sector, is characterized by the high degree of systemic complexity embodied in its products. Consequently, a substantial element of technological and marketplace uncertainty exists in the design and development

of each product. Aerospace companies have pursued production and design strategies aimed at insulating themselves from the adverse consequences of such uncertainty (Mowery, 1985).

Finally, the U.S. aerospace industry, principally the commercial aviation sector, has been the beneficiary of federally funded R&D for nearly a century. According to Mowery (1985), "The commercial aircraft industry is virtually unique among U.S. manufacturing industries in that a Federal research organization, the National Advisory Committee for Aeronautics (NACA),[2] and subsequently the National Aeronautics and Space Administration (NASA), has for many years conducted and funded research on airframe and propulsion technologies." The commercial aviation sector has also benefitted from considerable investment, in terms of research and procurement, by the Department of Defense. "Although not intended to support innovation in any but military airframe and propulsion technologies, [this investment] has, nonetheless, yielded indirect, but very important, technological spillovers to the commercial aircraft industry" (Mowery, 1985).

Implications For Federally Funded Civilian R&D

Both the NACA and NASA have been cited by scholars as models for Federal involvement in civilian R&D (Tiech, 1985) and precommercial research cooperation between industry and government (Nelson, 1982). Vannevar Bush (1945) proposed a similar model for the creation of his National Research

[2] Usage varies on the pronunciation of the names NACA and NASA. In this dissertation, NACA is meant to be read as four individual letters "N-A-C-A," while the acronym NASA as a two-syllable word.

Foundation that was based on the land-grant colleges and the NACA. "Both offered science, applied science, technology, and a system for coupling knowledge with people who would use it in the field" (Shapley and Roy, 1985). The apparent success of Federal involvement in aerospace contrasts sharply with the results of the Federal government's attempts to intervene in the innovation process in the automotive industry through initiatives such as the Cooperative Automotive Research Program (CARP) (Rosenberg, 1985).

Numerous reasons have been advanced for the failures of civilian technology programs such as CARP. Averch (1984) suggests that the failure of these initiatives lies with the application of an "engineering strategy" approach to the solution of broad economic and social problems such as declining productivity. Logsdon (1986) suggests that the failure of such programs is due to the "direct *involvement" of government in the marketplace,* implying that direct government involvement in economic affairs should be minimal. Mowery (1983) suggests that the failure of these programs is attributable to the application of an inappropriate theoretical economic framework, a framework that ignores or does not account for the effective transmission and utilization of complex research results and technological information. In particular, these programs ignore the abilities and limitations of organizations engaged in innovation to exploit extramural research, thus ignoring the relationship between knowledge production, transfer, and utilization as equally important components of the innovation process. Mowery (1985) further states:

> This theoretical [economic] framework focuses primarily on the putative undersupply of research and bases its recommendations for policy on this market failure. However, for policy purposes, the

> distribution and utilization of the results of research and development are crucial. An exclusive focus on the R&D support policies of the Federal government, without some cognizance of the substantial diffusion support component of the policy structure, yields conclusions that differ substantially from those of an analysis that attempts to incorporate both the technology supply and technology adoption incentives operating within the overall policy framework.

What reasons account for the apparent success of the Federal government's attempts to intervene in aerospace R&D? According to Mowery (1985), "Government policy in the aircraft industry not only supported precommercial research in civilian and military aircraft technologies, but it also has played a major role in supporting the diffusion of the results of that research." A retrospective look indicates that the Federal government has played an enormously significant role in both the "supply-push" and the "demand-pull" side of the aerospace knowledge diffusion process (March, 1989).

Supply-Push

The use of Federal policy to supply and push aerospace knowledge began with the creation of the National Advisory Committee for Aeronautics (NACA) by the Congress in 1915. The NACA was created to "supervise and direct the scientific study of the problems of flight with a view to their practical solutions and to give advice to the military air services and other aviation services of government" (The Naval Appropriations Act, 1916). In its wind tunnels and laboratories, the NACA worked on problems of aerodynamics and aeronautics common to both military and commercial aviation, guided by committees composed of representatives from the aviation industry, the military services, and academia.

Throughout its history, the NACA has been described as "arguably the most important and productive aeronautical research establishment in the world. Between its creation in 1915 and its demise in 1958, the NACA published more than 16 000 technical reports which were sought after and exploited by aeronautical engineers [and scientists] throughout the U.S. and abroad" (Roland, 1985). Many of these reports are classics in the field of aerodynamics and aeronautics and are still used and referenced; the data contained in these reports are essential to understanding the fundamentals of aeronautical research and design (Anderson, 1974). Additionally, the NACA maintained an "intelligence" office in Paris for the specific purpose of collecting, evaluating, translating, and disseminating the results of foreign aeronautical research to U.S. academic, government, and industry users.

The use of Federal policy to supply and push aerospace knowledge has been aided by the Department of Defense (DOD). Research supported by the DOD has yielded indirect, but very important, innovative spillovers to the commercial aircraft sector of the U.S. aerospace industry, most notably in the areas of airframe development, aircraft propulsion, avionics, and flight control systems. The demands of the military for performance pushed the development and early application of many technologies. The military supported jet engine development, provided continued support for the development of specific military engines whose cores were adapted for commercial use, and provided the test-beds for the technological development of early commercial jet aircraft (March, 1989).

The development of the first jet engine in the United States was financed entirely by the DOD, reflecting "both the perceived military urgency of the project,

and the lack of interest in the development of such an engine expressed by commercial aircraft firms prior to 1940" (Mowery and Rosenberg, 1982). Turbofan engine research for the C-5A, which led to the development of high-bypass-ratio engines, was adapted by the commercial aviation industry for the engines that power the Boeing 747, 757, and 767. The development of the KC-135 tanker laid the foundation for the Boeing 707, particularly with regard to the wings, tail, and power plant (Mowery, 1985).

Demand-Pull

Federal regulatory policy also affects the demand for knowledge by the commercial aviation industry. Passage of the Kelly Air Mail Act of 1925 transferred responsibility for airmail transport from the Post Office to private contractors. The contractors, who were paid on a weight basis, bid on the various routes. During the years 1925 to 1930, the Congress reduced airmail rates, creating a substantial increase in airmail volume. Reflecting the growth of the airmail market, the commercial aircraft industry responded by producing aircraft, such as the Boeing 40, that were designed for long-haul cargo transport (Mowery, 1985).

The McNary-Watres Act of 1930 changed the method of payment for carrying airmail from a weight basis to a space-mile (seat) basis. Carriers would, therefore, derive a greater portion of their revenues from passenger transportation. Additionally, incentive payments were made to carriers who used multiengine aircraft, radios, and other navigational aids. The McNary-Watres Act, which had the effect of developing a small number of financially strong transcontinental carriers, coincided with the rapid growth of air passenger traffic. The commercial

aircraft industry responded with the design of long-haul passenger transports such as the B-247 and the DC-2, which represented significant commercial aviation developments (Mowery and Rosenberg, 1982).

Congress created the Civil Aeronautics Board (CAB) in 1938, giving it the power to issue operating certificates, oversee airline fares, control pricing policies, and control entry to and exit from commercial air transportation. Multiple carriers, operating in a market where entry was controlled and price competition was prohibited, gave rise to a high level of service-quality competition. Acting on the belief that the rapid introduction of state-of-the-art aircraft was an effective marketing strategy, the major air carriers quickly adopted new aircraft designs. The drive to be the first with a new design motivated the major airlines to make early purchase commitments to airframe manufacturers as a means of obtaining the earliest possible delivery. Service-quality competition thus fostered rapid diffusion and adoption of innovations that drew upon federally funded research results. This same situation fostered fierce competition among airframe manufacturers, especially for aircraft that would capture the largest single markets, the transcontinental and transatlantic routes. Little or no heed was paid to the development of aircraft for short-range and low-density routes (Mowery and Rosenberg, 1982).

Recent Federal regulatory policy, in the form of domestic airline deregulation, has disrupted the supply-push and demand-pull knowledge production, transfer, and utilization equation by fundamentally shifting the primary axis of competition from service and quality to price. Price competition has the net effect of pressuring both the airlines and the airframe manufacturers to cut cost; it also

lessens the need for and the adoption of innovations. Many airlines have postponed or delayed purchase decisions and continue using existing aircraft (Leinster, 1984).

Airline deregulation has also affected route structure, thus altering fleet needs. Deregulation has replaced a point-to-point emphasis with a hub-to-spoke strategy that emphasizes short-range and low-density routes and has produced a mismatch between the existing fleets of larger, wide-body aircraft and the need for smaller commuter aircraft. CAB policies, which emphasized long-haul, point-to-point service, restricted the need for short-haul aircraft and, hence, their production by U.S. manufacturers. Their development was confined largely to Europe and Canada. One outcome of domestic airline deregulation has been the creation of a commuter airline market and the need for commuter aircraft. Rapid growth of this market has benefitted European, Canadian, and other foreign producers of these aircraft (March, 1989).

Implications

With its contribution to trade, its coupling with national security, and its symbolism of U.S. technological strength, the U.S. aerospace industry holds a unique position in the Nation's industrial structure (National Academy of Engineering, 1985). However, the U.S. aerospace industry, in particular the commercial aviation sector, is experiencing profound change created by a combination of domestic and international circumstances. Some features of the change result from domestic actions and circumstances such as airline deregulation, while others result from external trends and events such as emerging foreign competition (Hannay, 1986). Consequently, while the implications of the change

that is occurring are of national importance, the implications are not well understood. Hannay (1986) finds that four factors, events, and trends are changing the nature of the U.S. aerospace industry and the commercial aviation sector. The continuation of the domestic airlines' traditional role in launching new aircraft is uncertain due to economic deregulation and the deteriorating financial performance of domestic airlines.

Worldwide, the manufacture of aircraft is becoming an attractive industry and many foreign companies enjoy a special supportive (financial) relationship with their governments. Domestic air travel is projected to grow less rapidly than in foreign markets, so export sales will become increasingly important. Countries are demanding a participative role in manufacturing as the price of entry into their markets. Simultaneously, U.S. producers are seeking to spread risks and to develop additional capital. Thus, increasing U.S. collaboration with foreign producers results in a more international manufacturing environment. The changing composition of the industry will foster an increasing flow of U.S. aerospace trade. At the same time, international industrial alliances will result in a more rapid diffusion of technology, increasing pressure on the U.S. aerospace industry to push forward with new technological developments (U.S. Department of Commerce, 1988).

PROBLEM CONTEXT

To establish an organizing framework for *this* study, the process of innovation in the U.S. aerospace industry is conceptualized as an information processing system that must deal with work-related uncertainty through patterns of

technical communications. Throughout the innovation process, ideas and knowledge are being pursued and transferred. The fact that these ideas and knowledge deal with hard technologies or may be, as Allen (1977) states, "physically or hardware encoded," should not detract from the observation that, in aerospace R&D, the innovation process is fundamentally an information processing activity.

The premise that the process of innovation can be viewed as an information processing activity has its roots in open system theory (Katz and Kahn, 1966) and represents an extension of the arguments developed by Tushman and Nadler (1980). These arguments trace their origins to, among others, Galbraith (1973) and Duncan (1973), who have conceptualized organizations as information processing systems.

Uncertainty, defined as the difference between information possessed and information required to complete a task (Rosenbloom and Wolek, 1970), is central to the concept of *organizations as information processing* activities. Rogers (1982) states that **uncertainty** is the central concept in innovation behavior: "The act, and the process, of innovating is clearly one that involves grappling with unknowns. These unknowns or uncertainties may be technological, economic, or merely the manifestation of personal and social variables."

Rogers (1982) further states that "when faced with uncertainty, individuals typically seek information. Such information-seeking to cope with uncertainty is why communication behavior cannot be ignored when studying innovation. Because innovation behavior always entails coping with a relatively high degree of uncertainty, such innovation is, **most centrally**, an informational process."

An Information Processing Framework

Information processing in aerospace R&D (figure 1) is viewed as an ongoing problem-solving cycle involving various activities within the innovation process, the larger organization, and the external world. For purposes of *this* study, the innovation process is conceptualized as a process of related activities or units beginning with research at one end and service and maintenance on the other.[3]

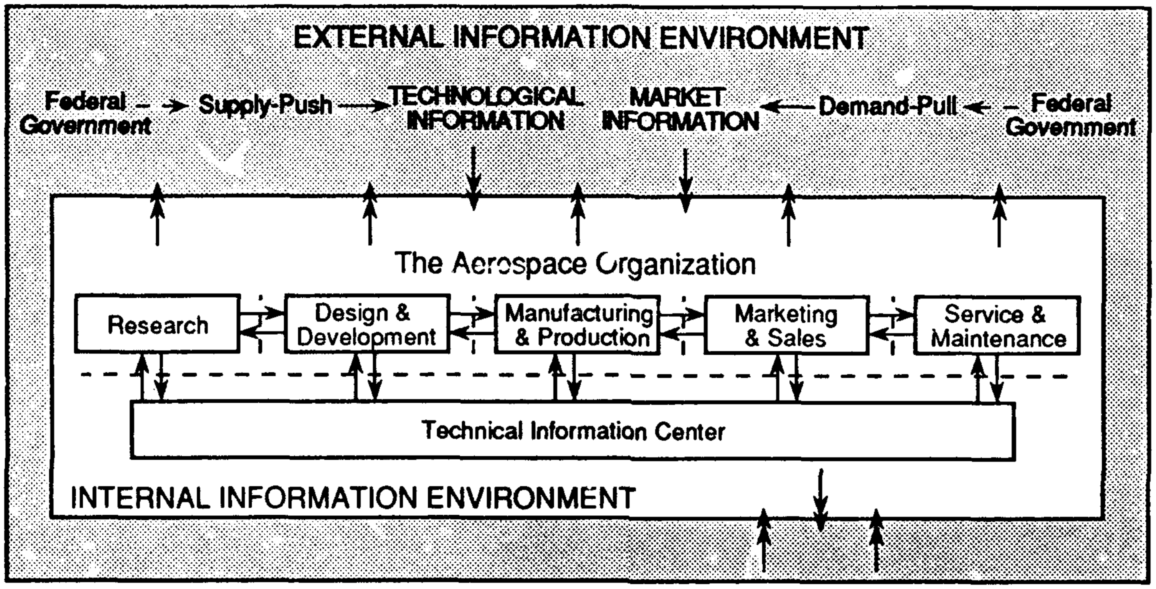

Figure 1. The Aerospace Innovation Process as an Information Processing System.

These activities or units are highly differentiated, however. They operate on different time frames and have different goals and varying professional orientations (Rosenbloom and Wolek, 1970). These differences in norms and values also carry with them different internal coding schemes that suggest that each unit may possess specific and unique information requirements and information processing patterns.

[3]The proposition that innovation is a linear process, a view presented by Myers and Marquis (1969), is not universally accepted. Langrish, et al., (1972) and Kline (1985) have rejected "linear models" of the innovation process as unrealistic.

The activities or units are also likely to have different sources of effective feedback, evaluation, and information support (Tushman and Nadler, 1980).

For any given task, each activity or unit within the innovation process "must [based on open system theory] effectively import technical and market information from the external information world" (Tushman and Nadler, 1980). New [external] and established [internal] information must be effectively processed within the work area; decisions, solutions, and approaches must be worked on and coordinated within each activity and within the organization; and outputs, such as decisions, processes, products, and information, must effectively be transferred to the external environment. The outputs of this process create conditions for another set of activities, thereby initiating another information processing cycle. Throughout the process, organizations must be sensitive to the differences between the activities or units that comprise the innovation process. Specialized feedback, evaluation, and support may be required to process new information from internal and external sources (Gerstberger, 1971).

Organizations involved in innovation are open systems that must deal with several sources of work-related uncertainty (Katz and Kahn, 1966). In particular, they must deal with technical and market uncertainty from outside the organization as well as uncertainty concerning problem solving within the organization (Myers and Marquis, 1969; Utterback, 1974). The nature of organizations involved in innovation is such that uncertainty cannot be eliminated. To maintain stability, however, organizations involved in innovation must constantly strive to reduce un-

certainty to a manageable level (Miller, 1971). Information is used by organizations to reduce work-related uncertainty (Tushman and Nadler, 1980).

Three factors (task characteristics, task environment, and task interdependence) combine to influence the degree of uncertainty with which organizations involved in the innovation process must contend. Uncertainty increases as the task becomes more complicated, as the environment becomes more dynamic, and as task interdependence becomes more complex. The greater the uncertainty, the greater the information processing requirements and the greater the need for information external to the organization (Rosenbloom and Wolek, 1970; Allen, 1970).

However, it is the nature of organizations engaged in innovation to isolate themselves from the outside world, to erect barriers to communication with their external environment, and to rely on information internal to the organization (Gerstenfeld and Berger, 1980). This behavior is due in large part to the need for organizations to exercise control over those situations in which they interact with the "outside," to reduce uncertainty, and because these organizations are frequently involved in activities of a proprietary nature (Fischer, 1980; Allen, 1970). Numerous studies have found a strong relationship between successful innovation, idea formulation, and information external to the organization (Dewhirst, et al., 1979; Allen, 1977; Science Policy Research Unit, 1972). The danger, then, for organizations engaged in innovation is to become isolated from their external environment and from information external to the organization (Fischer, 1980).

Government Influence on Information Processing

This condition of isolation is moderated somewhat, however, by the "supply-push/demand-pull" effect created by the Federal government's involvement, primarily through NASA and DOD, in the aerospace innovation process. The Federal government has become both a performer and a dominant purchaser of aerospace R&D. From a policy perspective, the aerospace industry is a main performer of Federal R&D and the academic community a main performer of basic research. According to Rosenberg (1985), "The role of the Federal government in the support of R&D is carried out within an institutional framework dominated [or characterized] by contractual relationships between the Federal government, the aerospace industry, and the academic community."

These contractual relationships, in and of themselves, contribute to the transmission and utilization of knowledge resulting from federally funded aerospace R&D. The transfer of knowledge is also aided by joint government-industry cooperative projects; technical committees composed of representatives from academia, government, and industry; the exchange of personnel; jointly sponsored workshops and conferences; and the use of government facilities by academia and industry. Additionally, both NASA and DOD maintain scientific and technical information (STI) systems for acquiring, processing, announcing, publishing, and transferring the results of government-performed and government-sponsored research. According to Stohrer (1981), within both the NASA and DOD STI systems, the U.S. government technical report is used as a primary means of transferring the results of this research to the aerospace community.

U.S. Government Technical Report

Figure 2 presents a model that depicts the transfer of federally funded aerospace R&D vis-à-vis the U.S. government technical report. The model is composed of two parts: the **informal,** which relies on collegial contacts, and the

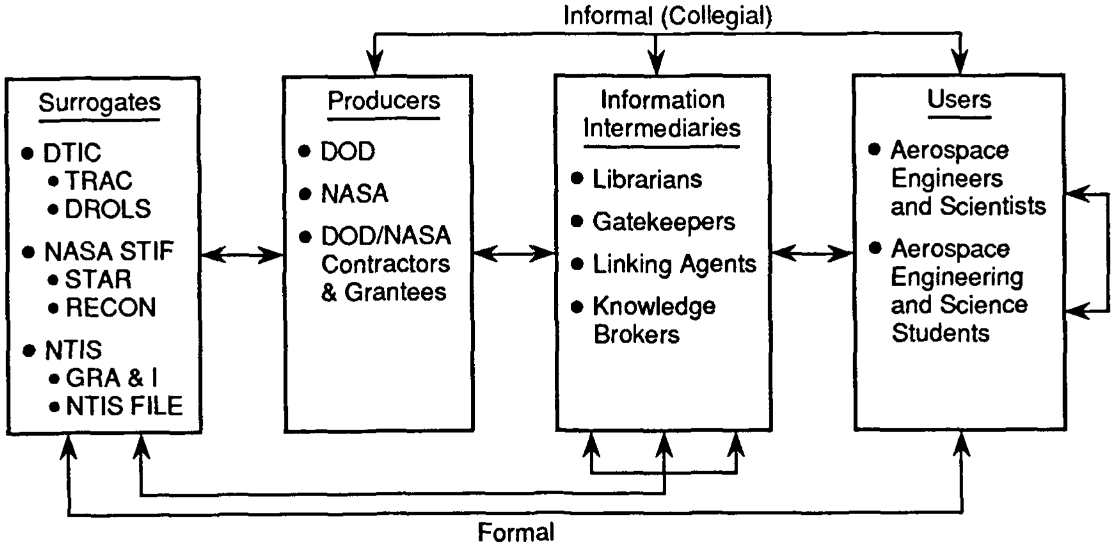

Figure 2. A Model Decipting the Transfer of Federally Funded Aerospace R&D.

formal, which relies on surrogates, information products, and information intermediaries to complete the transfer of knowledge from the "producer" to "user." The producers are DOD and NASA and their contractors and grantees. NASA and DOD publish U.S. government technical reports and make the initial or primary distribution to libraries and technical information centers. Surrogates receive copies for secondary and subsequent distribution. A limited number of reports are set aside as "author" copies to be used by the author for the "scientist-to-scientist" exchange of information.

Surrogates include the Defense Technical Information Center (DTIC), the NASA Scientific and Technical Information Facility (NASA STIF), and the National

Technical Information Service (NTIS). They serve as technical report repositories or clearinghouses for the producers. The surrogates, in turn, have created various technical report announcement journals such as TRAC (Technical Report Announcement Circular), STAR (Scientific and Technical Aerospace Reports), and Government Reports Announcements and Index (GRA&I) and computerized retrieval systems such as DROLS (Defense RDT&E On Line System), RECON (REmote CONsole), and the NTIS File that permit on-line access to technical report data bases.

Information intermediaries are, in large part, librarians and technical information specialists in academia, government, and industry. Those representing the producers serve as what McGowan and Loveless (1981) describe as "knowledge brokers" or "linking agents." Information intermediaries connected with users act, according to Allen (1977), as "technological entrepreneurs" or "gatekeepers." The more "active" the intermediary, the more effective the transfer process becomes (Goldhor and Lund, 1983). Active intermediaries take information from one place and move it to another, often face-to-face. Passive information intermediaries, on the other hand, "simply array information for the taking, relying on the initiative of the user to request or search out the information that may be needed" (Eveland, 1987).

What little is known about the U.S. government technical report in an empirical sense is limited and dated (Herner and Herner, 1961; O'Donnell, et al., 1962). Auger (1975) states that "the history of technical report literature in the U.S. coincides almost entirely with the development of aeronautics, the aviation industry,

and the creation of the NACA, which issued its first report in 1917."[4] In her study, Information Transfer in Engineering, Shuchman (1981) reports that 75 percent of the engineers surveyed used technical reports; that technical reports were important to engineers doing applied work; and that aerospace engineers, more than any other group of engineers, referred to "key" persons and technical reports. However, in many of these studies it is often unclear, as in Shuchman's study, whether U.S. government technical reports, non-U.S. government technical reports, or both are included (McClure, 1988).

McClure (1988) argues that "the [U.S. government] technical report is the primary means by which [the results] of Federal R&D are reported." There is some historical, but little empirical, evidence to support the claim that the U.S. government technical reports produced by the NACA played an important role in transferring the results of federally funded R&D to the U.S. aeronautical community (Roland, 1985). Paradoxically, while U.S. government technical reports "may constitute the single most important storehouse of R&D in the world, they may constitute the most ignored and inaccessible STI [product] in the world" (McClure, 1989). McClure (1989) further concludes that "we know very little about the role,

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[4]The complete citation to the first NACA technical report is given below.

Report on Behavior of Aeroplanes in Gusts. NACA Report 1 in Two Parts, 1915. Hunsaker, J.C. Part 1 - Experimental Analysis of Inherent Longitudinal Stability For a Typical Biplane. Wilson, E.B. Part 2 - Theory of an Aeroplane Encountering Gusts. In (1915) First Annual Report of the National Advisory Committee for Aeronautics. (Washington, DC: Government Printing Office, 1917,) 23.

importance, and impact of this literature vis-à-vis the transfer of federally funded R&D, U.S. innovation, and productivity."

What, then, is the role of the U. S. government technical report in the diffusion of knowledge resulting from federally funded aerospace R&D? What role does the U.S. government technical report play in an industry in which Federal science and regulatory policy influence knowledge diffusion? What role does the U.S. government technical report play in a mature industry that is becoming more interdisciplinary in nature and more global in scope?

STATEMENT OF THE PROBLEM

Numerous "user studies," investigations of the information-seeking habits and practices of engineers and scientists, have been performed over the past quarter of a century. User studies can be broadly grouped into two categories. One type is concerned primarily with the performance of an information service or system that is used by a particular group of engineers and scientists. A goal of these studies is frequently to determine the effectiveness of the service or system. The other type is concerned primarily with the impact of information or a particular information product on the task or the work being performed. Studies of this nature focus on the social system within which information is produced or used. *This* study fits into the latter category, being concerned with an exploration of the interface between the user, the task being performed, the information products used, and the criteria affecting the selection or use of a particular information product.

Conceptual Framework

The conceptual framework for the problem is based on the work of Orr and Mick, et al., (1979). Their research focused on developing a conceptual scheme for understanding and predicting the communication behavior of scientists, a generic term employed to cover both engineers and scientists.

Their work was grounded in the following three assumptions: (1) that a holistic or global view is necessary to understand and predict the scientists' communication behavior; (2) that the scientists' communication behavior can be viewed as a system of information input and output activities, can be characterized as a series of complex interactions, and is influenced or affected by a variety of factors; and (3) that these variables, either individually or grouped, influence information processing and, therefore, can be used to understand and predict the use and production of an information product and the scientists' communication behavior. Orr (1970) states that a number of studies have indicated that a scientist's information input and output activities are related or at least associated. Orr (1970) hypothesizes (figure 3) that some personal or situational variable(s) "X" is the major determinant of both input and output.

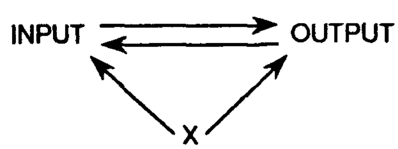

Figure 3. Relations Between Input and Output.

The Problem

The following question expresses the problem statement for this research. Which factors or variables explain the use of U.S. government technical reports by U.S. aerospace engineers and scientists? For purposes of *this* study, two sets of variables are said to influence the use of U.S. government technical reports by U.S. aerospace engineers and scientists. The first set, identified as institutional or structural variables, includes the following six factors: education, academic preparation, years of professional aerospace work experience, type of organization, professional duties, and technical discipline. Research conducted by Allen (1977), Fischer (1980), Fishenden (1959), Herner (1954), Olson (1978), Rosenbloom and Wolek (1970), Scott (1962), Seiss (1982), and Shuchman (1981) indicates that these variables influence the use of an information product as well as the information-seeking habits and practices of engineers and scientists.

The second set, identified as sociometric or source selection variables, include the following seven factors: accessibility, ease of use, expense, familiarity or experience, technical quality or reliability, comprehensiveness, and relevance. O'Gara (1968) refers to these variables as sociometric factors. Research conducted by Gerstberger (1967), Kaufman (1979,1983), Rosenberg (1966), and Werner (1965) indicates that these variables influence the use of an information product as well as the information-seeking habits and practices of engineers and scientists.

The conceptual framework for the problem, which is shown in figure 4, is an extension of Orr's (1970) model for predicting information product use, production, and behavior. This research follows Orr's work but with the following three dis-

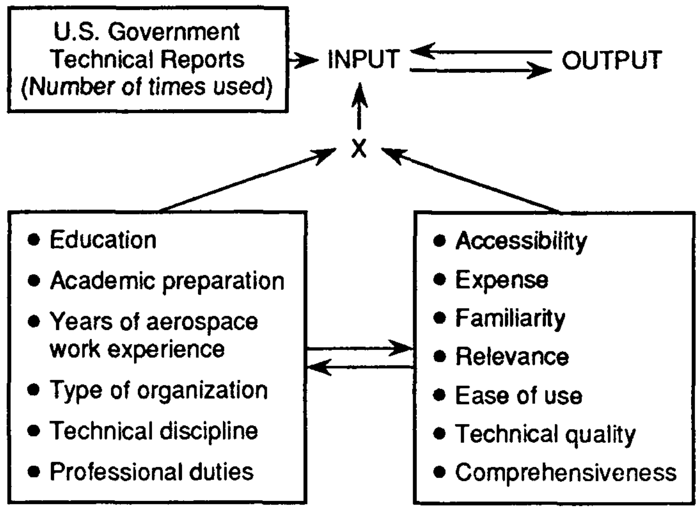

Figure 4. Relations Between U.S. Government Technical Reports as Input and Selected Institutional and Sociometric Variables.

tinctions: (1) while acknowledging an association between input and output, this research focuses on "input," the use of U.S. government technical reports; (2) although an inherent compatibility exists between input and output in the information processing system of science, a fundamental and inherent incompatibility exists between input and output in technology (Allen, 1977); and (3) whereas "scientist" continues to be used as a generic term for both engineers and scientists, the two groups are fundamentally different. The primary difference between engineers and scientists leads not only to different information-seeking habits and practices, but also to differences in the use and value that the two groups place on information (Joenk, 1985). The difference stems from two primary considerations: (1) the independent nature of science and technology (Allen, 1977; Shapely and Roy, 1985), and (2) the social enculturation of engineers and scientists (Allen, 1977; Krulee and Nadler, 1960; Holmfeld, 1970).

Research Questions

The goal of *this* study is to provide an empirical basis for understanding the role of the U.S. government technical report in the diffusion of knowledge resulting from federally funded aerospace R&D. Taking the view that the U.S. government technical report plays an important, but as yet undefined, role in the aerospace knowledge diffusion process, it follows that three research questions are generated. First, do the six institutional or structural variables explain the use of U.S. government technical reports by U.S. aerospace engineers and scientists? Second, do the seven sociometric or source selection variables explain the use of U.S. government technical reports by U.S. aerospace engineers and scientists? Third, if both the institutional and sociometric variables are considered, does one set of variables predominate in terms of use?

Hypotheses

The dependent variable in *this* study is the "number of times a U.S. government technical report was used in a 6-month period" by U.S. aerospace engineers and scientists. There are 13 independent variables. The hypotheses were formulated on "an assumption of difference" and, therefore, are stated as **alternative** hypotheses. Each hypothesis was tested with the statistical significance of $p < 0.05$.

Hypothesis 1. The amount of education, stated in terms of no graduate and graduate education degree, influences the number of U.S. government technical reports used in a 6-month period. Therefore, U.S. aerospace engineers and scientists having **only** an undergraduate education degree or less are more likely than their

counterparts with a graduate degree to use U.S. government technical reports. The assumption of difference is based on Allen's (1977) belief that "the long, complex process of academic socialization involved in obtaining an M.S. or a Ph.D. is bound to result in a person who differs considerably in his/her lifeview. These differences in values and attitudes toward work will almost certainly reflect in the behavior of the individual, especially in their use and production of information."

Hypothesis 2. Educational preparation, stated in terms of academic preparation to become either an engineer or a scientist, influences the number of U.S. government technical reports used in a 6-month period. Therefore, those survey respondents educated as engineers, as opposed to those educated as scientists, are more likely to use U.S. government technical reports. The assumption of difference is based on the COSATI Report, which states that "the technical report is favored as a recording medium of R&D and is, therefore, used by engineers and technologists, while the scientific journal appears to be favored as the recording medium of basic research and is, therefore, used by scientists" (Federal Council for Science and Technology, 1968).

Hypothesis 3. The number of years of professional work experience in aerospace, stated in terms of a 30-year career, influences the number of U.S. government technical reports used in a 6-month period. Those U.S. aerospace engineers and scientists having 15 years or less of professional aerospace work experience are more likely to use U.S. government technical reports than those having 16 years or more of professional aerospace work experience. The assumption of difference is based on Fischer (1980), who quotes Treadwell (1968),

stating that after the attainment of some peak level of performance, a researcher's effectiveness declines over time. Further, Pelz and Andrews (1966) found that technical communication, both in terms of frequency and time consumed, appears to decline with age.

Hypothesis 4. The type of organization, stated in terms of academia, government, and industry, to which U.S. aerospace engineers and scientists belong influences the number of U.S. government technical reports used in a 6-month period. Therefore, those survey respondents who work in a government organization, identified as DOD, NASA, and other, are more likely to use U.S. government technical reports than are those U.S. government aerospace engineers and scientists who work in academia and industry. The assumption of difference is based on Fischer's (1980) and Tushman and Nadler's (1980) observations that information internal to the organization constitutes the organization's institutional or corporate memory.

Information internal to the organization is also the information the professional is most likely to turn to first, especially when uncertainty is low. Allen (1977) found that engineers, performing nine separate functions such as learning new procedures, turn to internal information in the form of technical reports first for information for six of the nine functions. Therefore, it is assumed that professionals affiliated with U.S. government organizations would use the U.S. government technical report, which constitutes the information internal to government organizations.

Hypothesis 5. The type of professional duties, stated in terms of management and nonmanagement, performed by U.S. aerospace engineers and scientists influences the number of U.S. government technical reports used in a 6-month period. Those survey respondents performing nonmanagement duties are more likely than those performing management duties to use U.S. government technical reports. The assumption of difference is based on the presumption that the duties of managers and nonmanagers are fundamentally different. Consequently, these two groups would develop different information use and production strategies that would, in turn, manifest themselves as distinctive technical communication practices. Although not supported by convincing empirical evidence, the assumption of difference has been advanced by Mathes and Stevenson (1976) and Bozeman, et al., (1978).

Hypothesis 6. *The discipline or the nature of the work*, stated in terms of engineering or science, that best characterizes the work performed by U.S. aerospace engineers and scientists influences the number of U.S. government technical reports used in a 6-month period. Those survey respondents who characterize their work as engineering, as opposed to science, are more likely to use U.S. government technical reports. The assumption of difference is based on the observation of Bikson, et al., (1984) that the literature of choice is based in large part on the tradition of the discipline. Those disciplines considered to be "more science like" tend to prefer the scientific journal as the medium of communication, whereas the more technology-oriented disciplines tend to prefer the technical report as the medium of choice. Furthermore, Bikson and her colleagues (1984) state that the U.S. government

technical report serves as both a releasing mechanism and a contractual record for the major mission-oriented agencies, such as DOD and NASA, involved in aerospace R&D.

Hypothesis 7. Certain sociometric variables, identified as accessibility, ease of use, expense, familiarity or experience, technical quality or reliability, comprehensiveness, and relevance, influence the number of U.S. government technical reports used in a 6-month period. Of those sociometric variables considered, accessibility is most likely to influence the use of U.S. government technical reports. The assumption of difference is based on Allen's (1977) findings, which reveal a relationship between the frequency of information channel use and information channel performance. Gerstberger and Allen (1968), in their study of engineers and choice of an information channel, note:

> Engineers, in selecting among information channels, act in a manner which is intended not to maximize gain, but rather to minimize loss. The loss to be minimized is the cost in terms of effort, either physical or psychological, which must be expended in order to gain access to an information channel.

Their behavior appears to follow a "law of least effort" (Zipf, 1949). According to this law, individuals, when choosing among several paths to a goal, will base their decision upon the single criterion of "least average rate of probable work." According to Gerstberger and Allen (1968), engineers appear to be governed or influenced by a principle closely related to this law. They attempt to minimize effort in terms of work required to gain access to an information channel. Perceived **accessibility** appears to be the primary determinant in an engineer's selection of an information source.

Hypothesis 8. Thirteen variables, six institutional or structural and seven sociometric or source selection, are thought to influence or determine the use of U.S. government technical reports by U.S. aerospace engineers and scientists. A review of the relevant literature indicates that all these variables influence information use. Viewed as two groups, however, the institutional or structural variables tend to predominate or exert the greatest influence on information use. Therefore, it is proposed that, taken as a group, the structural or institutional variables determine the use of U.S. government technical reports by U.S. aerospace engineers and scientists.

OVERVIEW OF THE STUDY

With its contribution to trade, its coupling with national security, and its symbolism of U.S. technological strength, the U.S. aerospace industry holds a unique position in the Nation's industrial structure (NASA, 1986). However, the U.S. aerospace industry is experiencing profound change created by a combination of domestic policy actions such as airline deregulation, while others result from external trends such as emerging foreign competition (Hannay, 1986).

These circumstances emphasize the need to understand the aerospace knowledge diffusion process with respect to federally funded R&D; to recognize that STI emanating from federally funded aerospace R&D is a valuable strategic resource for innovation, problem solving, and productivity; and to remove the major barriers that restrict or prohibit the ability of U.S. aerospace engineers and scientists to acquire and process the results of federally funded aerospace R&D. However, as

Solomon and Tornatzky (1986) point out, "While STI, its transfer and utilization, is crucial to innovation [and competitiveness], linkages between [the] various sectors of the technology infrastructure are weak and/or poorly defined."

These conditions also intensify the need to understand the production, transfer, and utilization of knowledge as a precursor to the rapid diffusion of aerospace technology and as a means of maximizing the aerospace R&D process. Maximizing the aerospace R&D process begins with an understanding of the information-seeking habits and practices of U.S. aerospace engineers and scientists. As Menzel (1966) states:

> The way in which [aerospace] engineers and scientists make use of the information systems at their disposal, the demands that they put on them, the satisfaction achieved by their efforts, and the resultant impact on their future work are among the items of knowledge which are necessary for the wise planning of S&T information systems and policy.

Significance of the Problem

In terms of empirically derived data, very little is known about the diffusion of knowledge in the aerospace industry. Rogers (1983) defines diffusion as the "process by which an innovation is communicated through certain channels over time among members of the social system." Most of the channel studies, such as the work by Gilmore, et al., (1967) and Archer (1964), have been concerned with the transfer of aerospace technology to nonaerospace industries. Although researchers have investigated the information-seeking habits and practices of enginneers, it is not possible to determine from the published results if the study participants included aerospace engineers and scientists.

It is likely that an understanding of the process by which STI in the aerospace industry is communicated through certain channels over time among the members of the social system would contribute to increasing productivity, stimulating innovation, and improving and maintaining the professional competence of U.S. aerospace engineers and scientists. Furthermore, an empirically derived understanding of the process would permit the development of a conceptual framework for understanding both the information-seeking habits and practices of U.S. aerospace engineers and scientists and their behavior within the aerospace information social system. Such knowledge could be used by information and R&D managers to develop policies relative to U.S. aerospace innovation, productivity, and competitiveness and to develop and evaluate U.S. aerospace STI policy and systems.

Methodology

Survey research is the methodology used for the study. Data were collected by means of a self-administered mail questionnaire. The survey design is based primarily on Dillman's total design method (TDM) (Dillman, 1978). The approximately 34 000 members of the American Institute of Aeronautics and Astronautics (AIAA) served as the study population. The sample frame consisted of 6781 AIAA members (1 out of 5) who reside in the U.S and who are employed in academia, government, and industry. Systematic sampling was used to select 3298 members from the sample frame to participate in the study. Two thousand and sixteen (2016) usable questionnaires were received by the established cutoff date. With an adjusted sample of 2894 and 2016 completed questionnaires, the adjusted response rate for the survey was 70 percent.

Limitations

The generalizability of the data analysis is limited because the study focuses on U.S. aerospace engineers and scientists and U.S. government technical reports. The fact that only AIAA members are included in the sample also limits the generalizability of the data analysis. Further, the generalizability of the data analysis is limited because the sample is drawn from a professional society and does not include those who do not join professional societies. Finally, while the results help explain the use of U.S. government technical reports, the results cannot be used to predict report use.

Organization of the Study

The study is organized around five appendixes and seven chapters. The definitions of the terms used in the study appear in appendix A. The acronyms used in the study appear in appendix B. The questionnaire and associated correspondence appear in appendix C. Additional descriptive data tables for survey topics 1 and 2 appear in appendix D. The presentation of the descriptive data for survey topics 3 and 4 appears in appendix E. Chapter 1 contains the background, the problem context, the statement of the problem, and an overview of the study. Chapter 2 contains a review of the literature concerning U.S. government technical reports. A review of the literature concerning the information-seeking habits and practices of engineers is contained in chapter 3. The research design and methodology is found in chapter 4. The presentation of the descriptive data for survey topics 1 and 2 appears in chapter 5. The test of the hypotheses appears in chapter 6. The conclusions and recommendations for further research appear in chapter 7.

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CHAPTER 2

THE U.S. GOVERNMENT TECHNICAL REPORT AND THE DIFFUSION OF FEDERALLY FUNDED AEROSPACE R&D

INTRODUCTION

This chapter contributes to the immediate purpose of *this* study by establishing a framework for understanding the role played by the U.S. government technical report in the diffusion of federally funded aerospace R&D. To establish this framework, an overview of the U.S. government technical report, its unique aspects, its role in scientific and technical (S&T) communication, and its historical development are presented. The STI system that depicts the transfer of federally funded aerospace R&D from knowledge **producer** to knowledge **user**, vis-à-vis the U.S. government technical report, is described. Finally, to help create the conceptual framework, literature relevant to the U.S. government technical report is presented based on four themes.

BACKGROUND

World War II marked a sharp departure from the role previously played by the Federal government in science and technology with respect to financial support for research not directly or explicitly tied to a specific Federal agency or program. "In spite of the permissive implications of the **general welfare** clause of the U.S. Constitution, Federal support for science and technology prior to World War II had

been limited sharply by a strict interpretation of the role of the government" (Teich, 1985). Rosenberg (1985) provides the following historical observation:

> What has emerged since the Second World War is a system in which the Federal government has become the dominant purchaser of R&D, but without, at the same time, becoming the dominant performer of R&D. Thus, the unique institutional development has been the manner in which the Federal government has accepted a vastly broadened financial responsibility for R&D without arranging simultaneously for its in-house performance. Rather, private industry has become the main performer of Federal R&D, and the university community the main performer of the basic research component. Thus, the enlarged role of the Federal government in the support of R&D has been carried out within an institutional framework dominated by contractual relationships between the Federal government and private performers.

According to Teich (1985), the successful completion of such large-scale endeavors as the Manhattan Project "ushered in the age of truly **big science**. Also, it shaped the postwar imagination about the more constructive possibilities of science [and technology] when it could be applied in an organized and systematic way to the pursuit of human goals." Further justification for federally funded science and technology follows the argument advanced in *Science: The Endless Frontier* (Bush, 1945) that government-funded research in science and technology serves as a means to improve health, defend the nation, fuel economic growth, and provide jobs in new industries. Events such as the Korean War and Sputnik, the increased use of science and technology by the Federal government to solve social problems in the late 1960s and 1970s, the energy crisis, the "War on Cancer," the Vietnam War, and, more recently, a widening concern over the apparent decline in U.S. international competitiveness account for the growth of federally funded research in science and technology (National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, 1986).

The post-World War II expansion of the Federal government in science and technology resulted in significant changes in STI activities in the United States. These changes, which were necessary to handle the increased production of federally funded R&D, included new methods of publishing, disseminating, storing, and retrieving STI. According to Adkinson (1978), "A significant change occurred during this period in the way the results of federally funded research were disseminated. In the past, there had been almost complete reliance on dissemination through traditional journals and monographs; now, with the growth of federally funded science and technology, the use of the U.S. government technical report became widespread." According to McClure (1988), U.S. government technical reports "may constitute the single most important storehouse of R&D results in the world. These reports are a primary means by which the results of federally funded R&D are made available to the S&T community and are added to the literature of science and technology."

Characteristics of Technical Reports

The definition of the technical report varies because the report serves different roles in communication within and between organizations. The technical report has been defined etymologically, according to report content and method (U.S. Department of Defense, 1964); behaviorally, according to the influence on the reader (Ronco, et al., 1964); and rhetorically, according to the function of the report within a system for communicating STI (Mathes and Stevenson, 1976). The boundaries of technical report literature are difficult to establish because of wide variations in the content, purpose, and audience being addressed. The nature of the report -- whether it is informative, analytical, or assertive -- contributes to the difficulty.

Fry (1953) points out that technical reports are heterogenous, appearing in many shapes, sizes, layouts, and bindings. According to Smith (1981), "Their formats vary; they might be brief (two pages) or lengthy (500 pages). They appear as microfiche, computer printouts or vugraphs, and often they are loose leaf (with periodic changes that need to be inserted) or have a paper cover, and often contain foldouts. They slump on the shelf, their staples or prong fasteners snag other documents on the shelf, and they are not neat."

Technical reports may exhibit some or all of the following characteristics (Gibb and Phillips, 1979; Subramanyam, 1981):

- o Publication is not through the publishing trade.
- o Readership/audience is usually limited.
- o Distribution may be limited or restricted.
- o Content may include statistical data, catalogs, directions, design criteria, conference papers and proceedings, literature reviews, or bibliographies.
- o Publication may involve a variety of printing and binding methods.

The SATCOM report (National Academy of Sciences - National Academy of Engineering, 1969) lists the following characteristics of the technical report:

- o It is written for an individual or organization that has the right to require such reports.
- o It is basically a stewardship report to some agency that has funded the research being reported.
- o It permits prompt dissemination of data results on a typically flexible distribution basis.
- o It can convey the total research story, including exhaustive exposition, detailed tables, ample illustrations, and full discussion of unsuccessful approaches.

The Role of the Technical Report in S&T Communication

Technical reports and S&T journals are two of the primary information products used by engineers and scientists to communicate the results of their research. The choice of whether to publish the results of federally funded R&D in a technical report or an S&T journal depends on such factors as the nature of communication within the discipline, the type of information being reported, the reporting requirements of the sponsoring Federal agency, the timing of dissemination, and the need for selective or controlled dissemination. In practice, however, the technical report is favored as a recording medium of R&D and is, therefore, used by engineers and technologists, while the S&T journal appears to be favored as the recording medium of basic research and is, therefore, used by scientists (Federal Council for Science and Technology, 1968; AKA the COSATI Report).

During the past 45 years, the technical report has developed into an important medium of communication in science and technology to the extent that it has sometimes been viewed as a threat to the S&T journal (Pasternack, 1966). However, the technical report has been accused of not meeting the same criteria or standards of authority, scientific rigor, and retrievability as S&T journal articles (Brearley, 1973). Much of the debate concerning technical reports centers around the following four themes: (1) availability, (2) quality, (3) diversity of content, and (4) status as primary information products, especially in relationship to S&T journals (McCullough, et al., 1982).

History and Growth of Technical Report Literature

In describing the development of S&T communication, Grogan (1982) states that dissemination of research results was made first through personal correspondence and then through papers given at society meetings. As science became more specialized and institutionalized, the S&T journal became the accepted method of reporting research results. However, as the growth of science and technology began to escalate rapidly, the S&T journal was no longer capable of meeting the total information needs of engineers and scientists. According to Grogan the technical report emerged as an alternative method of disseminating the results of research.

The development of the [U.S. government] technical report as a major means of communicating the results of R&D, according to several authorities such as Godfrey and Redman (1973), dates back to 1941 and the establishment of the U.S. Office of Scientific Research and Development (OSRD). Further, the growth of the U.S. government technical report coincides with the post-World War II era and the expanding role of the Federal government in science and technology. However, U.S. government technical reports have existed for some period of time. The Bureau of Mines *Reports of Investigation* (Redman, 1965/66), the *Professional Papers of the United States Geological Survey*, and the *Technological Papers of the National Bureau of Standards* (Auger, 1975) are early examples of U.S. government technical reports. The first U.S. government publications identified as technical reports may have been those published by the National Advisory Committee for Aeronautics (NACA). Many NACA technical reports, which were published from 1917 to 1958, are classics in the field of aeronautics and are still used and referenced (Anderson, 1974).

THE TRANSFER OF FEDERALLY FUNDED R&D

The Federal government funds a major portion of the R&D in the United States, and it is estimated that $61 billion will be spent on Federal R&D in 1990 (National Science Foundation, 1989). A substantial portion of the Federal R&D expenditure is allocated to three agencies -- the Department of Defense (DOD), the Department of Energy (DOE), and the National Aeronautics and Space Administration (NASA). The results of this expenditure are transferred through a two-part system. The U.S. government technical report is a primary means by which these results are made available to the S&T community (Stohrer, 1981).

The model (figure 2) that depicts the transfer of federally funded R&D vis-à-vis the U.S. government technical report is composed of the formal and informal parts. The **formal** part relies on surrogates, specialized information products, and information intermediaries to complete the transfer of knowledge from "producer" to "user." The primary producers of federally funded R&D are DOD, DOE, and NASA. The surrogates include the Defense Technical Information Center, the NASA Scientific and Technical Information Facility, and the National Technical Information Service (NTIS). Information intermediaries are, in large part, librarians and technical information specialists in academia, government, and industry. An overview of the DOD, DOE, and NASA STI systems and of the NTIS follows.

DOD STI - Defense Technical Information Center

Situated at Cameron Station, Alexandria, Virginia, the Defense Technical Information Center (DTIC) is the central point within DOD for acquiring, storing,

retrieving, and disseminating STI to support the management and operation of DOD research, development, engineering, and studies programs (U.S. Department of Defense, 1985). Access to the results of defense-related research began in 1947, when the Office of Naval Research (ONR) contracted with the Library of Congress (LC) to establish the Science and Technology Project (STP) to catalog and abstract Navy technical reports and to provide bibliographic services for them (Tallman, 1962).

In 1951, the Secretary of Defense established the Armed Services Technical Information Agency (ASTIA) to coordinate and consolidate all DOD STI activities. In 1963, ASTIA was renamed the Defense Documentation Center (DDC); its operational control was transferred to the Defense Logistics Agency in 1979 (U.S. Department of Defense, 1985).

DTIC STI products and services are based on the agency's collection of over one million U.S. government technical reports and its computerized technical report data base. DTIC holds DOD technical reports that are classified for reasons of national security, that have restricted or limited distribution, or that are otherwise not publicly available. Unclassified and declassified technical reports that have no distribution limitations and have been released to the public are sent to NTIS.

DTIC has created a variety of STI products and services to provide access for registered users to its technical report collection and data base. The Defense RDT&E On Line System (DROLS), an interactive system linking remote terminals to the DTIC data base, is used for both retrieval and input. Users can order bibliographies, management data reports, and technical reports directly from their terminals. The recently cancelled *Technical Report Awareness Circular* (TRAC), which had replaced

Technical Abstracts Bulletin (TAB), was the unclassified-unlimited announcement journal for unclassified-unlimited, unclassified-limited, and classified DOD technical reports. TRAC, which was published monthly, included citations but no abstracts or subject index, contained five indexes, and had a semiannual-annual index that was published on microfiche.

The *Current Awareness Bibliography* (CAB) is a customized, automated bibliography based on the subject interests of DTIC users. Every two weeks the user's interest profile is matched against newly accessioned technical reports, and the selected citations are sent to the subscriber. Under the Automatic Document Distribution (ADD) program, DTIC users establish profiles of their interests; every two weeks they receive microfiche copies of newly acquired technical reports that match those interests (U.S. Department of Defense, 1985; Molholm, et al., 1988).

DOE STI - Office of Scientific and Technical Information

The Department of Energy (DOE) STI system is administered by the Office of Scientific and Technical Information (OSTI), which operates the Technical Information Center (TIC) located in Oak Ridge, Tennessee. The DOE STI system originated in 1942 with the Technical Information Service (TIS) of the Atomic Energy Commission (AEC). TIS became the Technical Information Center of the Energy Research and Development Administration (ERDA) and then the Technical Information Center of DOE.

The DOE technical report collection, currently 775 000 reports, grows by about 20 000 reports annually. DOE technical reports are distributed through a selective automatic distribution system. Unclassified-unlimited reports are supplied to NTIS and

the Government Printing Office (GPO) for further distribution to academic institutions, industry, and the public (Coyne, Hughes, and Winsbro, 1986).

OSTI has created a variety of STI products and services, including three data bases: the Energy Data Base (EDB), which covers all aspects of energy and energy sources; Nuclear Science Abstracts (NSA), which covers international nuclear science and technology research; and Research in Progress (RIP), which covers recently completed and ongoing projects funded by DOE. These data bases are available through commercial, on-line retrieval systems. Qualified users can access the data bases through the DOE national on-line information retrieval network, OSTI Automated Retrieval System (OARS). OSTI also publishes a variety of current-awareness documents, including *Energy Research Abstracts,* a biweekly announcement journal for technical reports; *Energy Abstracts for Policy Analysis,* a monthly announcement journal covering policy-related energy literature; and a variety of specialized bulletins covering such topics as acid precipitation and laser research (U.S. Department of Energy, 1987).

NASA STI - NASA Scientific and Technical Information Facility

The NASA STI system is administered by the Scientific and Technical Information Division. The mission of the NASA STI system is to acquire worldwide research information in aeronautics, space, and related disciplines, and to contribute to the expansion of knowledge through the timely dissemination of the results of NASA-performed and NASA-sponsored research to the aerospace community. NASA was created in 1958 by the National Aeronautics and Space Act (P.L. 85-568) to supersede the NACA, an agency that published its first technical report in 1917.

The NASA collection of 1.5 million technical reports grows by approximately 45 000 reports each year. Like those of DOE, NASA technical reports are distributed through an automatic distribution system. Unclassified-unlimited reports are supplied to NTIS and GPO for further distribution to academic institutions, industry, and the public. NASA technical reports that are classified for reasons of national security, that are restricted or limited in distribution, or that are otherwise not publicly available are obtained from the NASA Scientific and Technical Information Facility (STIF), located at the Baltimore-Washington International Airport (Wente, 1990).

The NASA STI system utilizes a variety of information products and services to provide access to the NASA technical report collection data base. *Scientific and Technical Aerospace Reports* (STAR), an announcement journal, covers worldwide aerospace technical report literature. *Selected Current Aerospace Notices* (SCAN), a current-awareness publication, supplements STAR by providing users with computer-generated citations to new reports announced in STAR. The NASA data base is accessible to authorized users through RECON, the NASA computerized on-line, interactive retrieval system. The unclassified portion of the NASA data base is commercially available through DIALOG's Aerospace Data Base (Wente, 1990).

National Technical Information Service

The NTIS has its origin in the Publications Board (PB), which was established in 1945. Its purpose was to collect and distribute unclassified and declassified technical reports produced by U.S. government agencies and foreign government research agencies as well as reports captured in World War II. In 1946, the name of the PB was changed to the Office of Technical Services (OTS). In 1964, OTS was

renamed the Clearinghouse for Federal Scientific and Technical Information (CFSTI). In 1970, CFSTI was abolished and its functions were transferred to the newly created NTIS.

The NTIS bibliographic data base includes unclassified-unlimited and declassified U.S. government technical reports that DOD, DOE, and NASA access and send to NTIS on magnetic tape. These tapes are merged with entries from other Federal, non-Federal, and foreign sources every two weeks to produce the *NTIS Bibliographic Database Update File,* which is distributed to a number of commercial vendors for on-line access.

Technical reports acquired by NTIS are announced in *Government Reports Announcements and Index* (GRA&I), which is published biweekly and may be purchased directly from NTIS in paper copy or microfiche. The reports may be received automatically through a biweekly current awareness service, *Selected Research in Microfiche* (SRIM), which provides full-text microfiche copies of reports selected by means of a preestablished interest profile. Other NTIS products and services include the *NTIS Abstract Newsletter,* a current awareness service; access to bibliographic data bases from other U.S. government agencies; and access to *Federal Research in Progress* (FEDRIP), computer software, translations, government patent information, and various fact sheets (U.S. Department of Commerce, 1986).

A Review of the Federal STI System

In their investigation, which focused on ways to improve the transfer of knowledge generated by federally funded research in science and technology, Bikson, et al., (1984) note three problems with the Federal STI system. First, the very low

level of support for knowledge transfer in comparison to knowledge production suggests that dissemination efforts are not viewed as an important component of the R&D process. Second, there are mounting reports from users about difficulties in getting appropriate information in forms useful for problem solving and decision making. Third, rapid advances in many areas of science and technology can be fully exploited only if they are translated into further research and applications. Such translation requires multidisciplinary, problem-focused communication of STI. Traditional transfer mechanisms, such as those used to transfer federally funded STI, do not provide that kind of communication.

In their study of the Federal role in the transfer and use of federally funded STI, Ballard, et al., (1986) conclude that" the present system for transferring the results of federally funded STI is passive, fragmented, and unfocused." They further state that "effective knowledge transfer is aggravated by the fact that the Federal government has no coherent or systematically designed approach to transferring the results of federally funded R&D to the users."

Eveland (1987) states that there have been a number of studies in recent years specifically concerned with the transfer of STI and U.S. industrial competitiveness. Although they offer no comprehensive explanation, Bikson, et al., (1984) state "much of what has been learned about knowledge transfer has not been incorporated into federally funded information transfer activities." Many of the individuals interviewed by Bikson, et al., state that "dissemination activities were afterthoughts, undertaken without serious commitment by Federal agencies whose primary concerns were with [knowledge] production and not with knowledge transfer."

Two problems exist with the **formal** part of the Federal STI system. First, the **formal** part of the system employs one-way, source-to-user transmission. The problem arises because formal, one-way, "supply side" transfer procedures do not seem to be responsive to the user context (Bikson, et al., 1984). Rather, these efforts appear to start with an information system into which the producers later try to retrofit the users' requirements (Adam, 1975). The consensus of the findings from the empirical research is that interactive, two-way communications are required for effective information transfer (Bikson, et al., 1984).

Second, the **formal** part relies heavily on information intermediaries to complete the knowledge transfer process. However, a strong methodological base for measuring or assessing the effectiveness of the information intermediary is lacking (Beyer and Trice, 1982; Kitchen, 1989). Therefore, the empirical findings on the effectiveness of these individuals and the role(s) they play in knowledge transfer are sparse and inconclusive. The impact of the information intermediary is likely to be strongly conditional and limited to a specific institutional context, and may be costly to maintain (Bikson, et al., 1984).

Two investigations specifically concerned with the dissemination of U.S. government technical reports were found. In an evaluation and appraisal of the effectiveness with which the existing system satisfies the Federal government's need for disseminating the results of federally funded STI promptly and effectively, O'Donnell, et al., (1962) conclude that "the present degree of effectiveness is unsatisfactory and that improvements to the Federal technical information distribution system are possible in several areas." Herner and Herner (1961), in their inquiry into

the factors governing the publication and announcement of U.S. government technical reports, conclude that announcement is slow and spotty and that the number of reports announced versus the number of unclassified reports available is small by comparison.

Studies of the DOD, DOE, NASA, and NTIS information systems and services have been performed. Some empirical investigations relate tangentially to the problem. None of these investigations, however, are directly concerned with the transfer of federally funded STI or U.S. government technical reports. The study by McClure, Hernon, and Purcell (1986), which explores the use of NTIS services and products by academic and public libraries, is noteworthy. The investigation by Finch (1988) into the factors responsible for the decline in sales of technical reports at NTIS is also worthy of mention. Several dissertations, such as Hernon's (1978), are concerned with the use and nonuse of U.S. government publications, not with U.S. government technical reports. Klempner's (1967) dissertation is concerned with the distribution patterns of U.S. government indexing and abstracting services such as STAR and TAB.

REVIEW OF THE RELEVANT RESEARCH

To further develop the conceptual framework for the study, literature considered relevant to U.S. government technical reports is grouped according to the following four topics:

- o Role in the Federal STI system
- o Role in Federal mission-oriented STI programs
- o Role in S&T communication
- o Historical development, use in specific disciplines, obsolescence, problems, coverage, and research needs

Selected findings, recommendations, and contributions addressing these topics are summarized in tables 1-4. This material sets the general tone of the research and literature related to technical reports and U.S. government technical reports. Although comprehensive, the list is not exhaustive.

Table 1 presents a small sampling of the more than 50 studies relative to Federal STI that have been conducted over the past 30 years. World War II resulted in an expanded Federal role in science and technology and signaled the "beginning of the era in which it was assumed that the [Federal] government had the primary responsibility to support and control STI" (Ballard, 1986). The primary argument for this assumption stems from the role of the Federal government as a major funder of R&D and the corresponding need for a uniform Federal approach to disseminating the results of federally funded R&D.

However, while numerous pieces of legislation affecting the creation, distribution, use, and dissemination of STI have been enacted, Federal STI policy is sketchy and uncoordinated. The demise of COSATI with its coordinating function and the resulting decentralized STI activities, the abolishment of the NSF Office of Science Information and its focus on STI research, and the questionable viability of the Office of Science and Technology Policy (OSTP) have left the Federal government with no coherent, centrally organized, and systematically designed approach to STI transfer (McClure, Hernon, and Relyea, 1989). Testifying before the U.S. House of Representatives Subcommittee on Science, Research, and Technology on Federal STI policy, Joseph G. Coyne (1989), speaking on behalf of the Federal interagency group CENDI, stated:

> The U.S. does not have an overall [STI] strategy, and it does not have a focal point to develop one. There are a number of laws, regulations, and standards now under consideration that could have a major impact on [Federal] STI programs. However, at the Federal level, there is no focal point for coordination [of STI] issue identification, and resolution.

Table 2 contains a listing of the studies specifically concerned with the DOD, DOE, and NASA STI programs. While not specifically concerned with the U.S. government technical report, some of the findings are relevant. The DOD user studies (Berul, et al., 1965 a&b; Goodman, et al., 1966 a,b,&c) conclude that the DOD technical information system is not widely used by DOD engineers and scientists. Roderer, et al., (1983) report that users read approximately 12.4 million DOD technical reports annually, that bibliographic search is the method most often used to identify DOD technical reports, and that education and research are the purposes for which DOD technical reports are most often read.

In their study of the DOE Energy Data Base, King, et al., (1982) report that users read 6.6 million DOE technical reports annually. DOE technical reports are identified through various means: 12 percent through computer search, 16 percent through a printed index, and the remaining 72 percent through other means such as browsing and standard distribution.

Monge, et al., (1979) report that NASA technical reports are widely used in the aerospace community. NASA technical reports are most frequently used to maintain professional awareness, to develop new ideas, and to validate research. Respondents to the Monge study cite the absence of detailed summaries and abstracts, the exclusion of negative data or findings, and insufficient tabular data as deficiencies in NASA technical reports.

Tables 3 and 4 contain the research relevant to the U.S. government technical report. The U.S. government technical report is a primary means by which the results of federally funded R&D are made available to the S&T community and are added to the literature of science and technology (President's Special Assistant for Science and Technology, 1962). McClure (1988) points out that "although the [U.S.] government technical report has been variously reviewed, compared, and contrasted, there is no real knowledge base regarding the role, production, use, and importance [of this information product] in terms of accomplishing this task." A review of the literature identified in tables 3 and 4 supports the following conclusions reached by McClure:

- o The body of available knowledge is simply inadequate and noncomparable to determine the role played by the U.S. government technical report in transferring the results of federally funded R&D.
- o Further, most of the available knowledge is largely anecdotal, is limited in scope and dated, and is unfocused in the sense that it lacks a conceptual framework.
- o The available knowledge does not lend itself to developing "normalized" answers to questions regarding U.S. government technical reports.

While the literature review does contribute to the immediate purpose of the study, it falls short of answering the fundamental research questions posed by this study. The role played by the U.S. government technical report in the diffusion of federally funded aerospace R&D is unknown. The extent to which the six institutional or structural variables influence the use of U.S. government technical reports is not known. Finally, the extent to which the seven sociometric or source selection variables influence the use of U.S. government technical reports cannot be determined from the available literature.

Table 1. Role of the U.S. Government Technical Report in the Federal STI System

Year	Author	Findings and recommendations
1962	Crawford (President's Special Assistant for Science and Technology)	Recognized that government technical reports constitute an important element in STI system; their principal value (use) is in the documentation of federally funded research.
		Government technical reports should be stored in an organized collection and placed under bibliographic control to facilitate their announcement, accessibility, and availability to the S&T community.
1963	Weinberg (President's Special Advisory Committee)	Recognized the problems that the proliferation of government technical reports caused the library and information community.
		Government has the obligation to publish all significant R&D findings; critical reviews, similar to those given S&T journal literature, should be applied to government technical reports; government-wide clearinghouses should be established to help integrate the results of government-funded R&D in the literature of science and technology; and the OTS should become a complete sales agency for government technical reports.
1964	Elliott (U.S. Congress, House of Representatives, Select Committe on Government Research)	Recognized the importance of technical reviews; concerned as to the type(s) of controls placed on dissemination; and recognized the need to properly index, abstract, and make government technical reports accessible to the S&T community.
		A single clearinghouse to coordinate Federal STI documentation and dissemination activities is needed; furthermore, the need exists to ensure that classified or otherwise restricted government technical reports do not remain unavailable to the S&T community any longer than is essential to the national interest.

Table 1. Concluded

Year	Author	Findings and recommendations
1968	COSATI (Federal Council for Science and Technology)	Recognized that the government technical report and the S&T journal are both essential in disseminating the results of federally funded R&D; both play important and different roles in S&T communication. Federal report-producing agencies must insist on full and high-quality reporting of all government-funded research.
1969	SATCOM (National Academy of Sciences-National Academy of Engineering)	Recognized the need to more effectively communicate the results of federally funded R&D; recognized the role of the government technical report in documenting and disseminating these results. Government technical reports must be given uniform and adequate bibliographic control; the writing and presentation of data must be improved; accessibility, through better and more fully coordinated announcement, must be increased; and maximum coordination between government technical reports and S&T journals must occur to minimize confusion and undesirable duplication.
1989	U.S. Congress, Office of Technology Assessment (OTA Staff Paper)	The Federal government is the largest single source of scientific and technical information (STI) in the world; OTA found that the government does not have an overall strategy on dissemination of STI including government technical reports; an overall strategy would help (1) maximize the return on the substantial Federal R&D investment and (2) meet other national goals to which STI can contribute, such as improving the education of U.S. scientists and engineers, the international competitiveness of U.S. industry, and the strength of the U.S. civilian technology base.

Table 2. Role of the U.S. Government Technical Report in Federal Mission-Oriented STI Programs

Year	Agency	Author	Contributions
1965 1966	DOD DOD	Berul, et al. Goodman, et al.	DOD User-Needs Studies—first large-scale attempts by a major component of the Federal communication community to determine the "broad picture" and understand information acquisition flow and use of STI (including DOD technical reports) within a large segment of the R&D community.
1983	DOD/DTIC	Roderer, et al.	Use and value of DTIC products and services—attempted to determine the economic value associated with DTIC products, including DOD technical reports; determined use, purpose of use, and readership of DOD technical reports.
1982	DOE/OSTI	King, et al.	Value of energy data base—attempted to determine the economic value of the DOE energy data base; determined time (hours) spent reading DOE technical reports and the use and purpose for using DOE technical reports.
1979 1980 1981 1989	NASA NASA NASA NASA	Monge, et al. Glassman and Cross Glassman and Glassman Glassman	Assessment of NASA technical information—concerned with the dissemination and utilization of NASA STI within the aeronautics industry; determined the knowledge and use of NASA STI products and services and the perceived quality and usefulness of NASA technical reports.
1982 1982	NASA NASA	McCullough, et al. Glassman and Cordle	NASA technical report format—concerned with the NASA technical report as a rhetorical device; analyzed and compared the NASA technical report format with current practice and usage.

Table 3. Role of the U.S. Government Technical Report in S&T Communication

Year	Author	Findings and recommendations
1956, 1957	Gray and Rosenborg	Most "publishable" STI contained in unclassified defense-related government technical reports did find its way into the S&T literature, but the process was slow. Authors should be encouraged to publish "publishable" findings promptly; government technical reports should be accessible to the S&T community several years after publication.
1961 1962	Herner and Herner Herner and Kolber	Probability of a government technical report appearing in a nongovernment abstracting and indexing service was low; average time from issuance to announcement of DOD technical reports in U.S. government announcement literature was slow. Federal government should take the necessary steps to encourage nongovernment abstracting and indexing services to include government technical reports, and the process of announcing DOD technical reports should be expedited.
1962	O'Donnell, et al.	The Federal systems used to disseminate government technical reports were ineffective and in some cases wasteful. Recommended coordinated government-wide policy for technical report documentation and dissemination.
1964	Ronco, et al.	Virtually no empirical work had been conducted to determine the effectiveness of government technical reports as communication devices. Federal technical-report-producing agencies should develop methods to test the effectiveness of technical reports as dissemination devices. Experimental formats for technical reports should be developed and tested to determine their effectiveness.

Table 4. The U.S. Government Technical Report: Historical Development, Use in Specific Disciplines, Obsolescence, Problems, Coverage, and Research Needs

Year	Author	Findings and recommendations
1952; 1962 1962; 1970	Miller; Tallman Kee; Boylan	Traced the historical development of government technical reports.
1953; 1958; 1961 1965 1967 1969	Cobb; Wilson; Burton and Green Garvey and Griffith Fuccillo Coile	Discussed the use of government technical reports by electrical and electronic engineers and in psychology, physics, and biomedicine.
1967; 1969 1973; 1975 1981; 1982	Houghton; Passman Brearley; Auger Subramanyam; Grogan	Discussed the role of the government technical report in S&T communication.
1959; 1960 1966; 1958, 1964; 1974	Randall; Burton and Kebler Pasternack; Wilson; Anderson	Discussed obsolescence and "half-life" of government technical reports.
1952; 1953; 1967 1970; 1978	Bennington; Fry; Boylan Boylan; Newman and Amir	Discussed the organization and management of government technical reports.
1953; 1965/1966 1966; 1967; 1967 1981	Woolston; Redman Hartas; Boylan; Klempner Henderson	Discussed problems with obtaining, handling, processing, and controlling technical reports.
1959, 1986 1988	Herner and Herner McClure	Discussed government technical report coverage and research needs.

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CHAPTER 3

THE INFORMATION-SEEKING HABITS AND PRACTICES OF ENGINEERS AND THE DIFFUSION OF FEDERALLY FUNDED AEROSPACE R&D

INTRODUCTION

This chapter contributes to the broader purpose of the study by establishing a framework for understanding the information-seeking habits and practices of U.S. aerospace engineers and scientists. To establish this framework, the nature of science and technology, the differences between engineers and scientists, and an overview of engineering STI studies are presented. Selective results of an exploratory study that investigated the technical communications practices of U.S. aerospace engineers and scientists are presented to further develop the conceptual framework. Finally, to further develop the conceptual framework, literature relevant to knowledge diffusion and technological innovation is presented based on four themes.

BACKGROUND

The President's Commission on Industrial Competitiveness (1985) concluded that "the nation's ability to compete has declined over the past twenty years; that we **must** be able to compete [internationally] if we are going to meet our national goals of a rising standard of living; and that we, as a nation, can no longer afford to ignore the competitive consequences of our actions or our inactions." American productivity,

which is at the heart of competitiveness, has been surpassed by the world's major industrialized nations (Porter, 1990). Since 1965, 7 out of 10 U.S. high-technology industries have lost world market shares (Young, 1985). The exception is the aerospace industry, which continues as the leading positive contributor to the United States balance of trade among all merchandise industries (U.S. Department of Commerce, 1990).

In his study of the commercial aviation sector of the aerospace industry, Mowery (1985) concludes that R&D investment resulted in dramatic productivity increases. Mowery further states that "total factor productivity in this [commercial aviation sector] industry has grown more rapidly than in virtually any other U.S. industry during the postwar period." U.S. aerospace industry leads all other industries in expenditures for R&D. The National Science Foundation (1989) estimates that total R&D expenditures on U.S. aerospace projects reached $24 billion in 1988. The Federal government, primarily through NASA and DOD, funds a substantial share of aerospace R&D to encourage basic research, generic product development, and improvements in flight safety (U.S. Department of Commerce, 1990).

However, the U.S. aerospace industry, in particular the commercial aviation sector, is in the midst of profound change and now faces a significantly more challenging competitive and global environment (National Academy of Engineering, 1985). The MIT Commission of Industrial Productivity (Dertouzos, et al., 1989) reinforces this position, stating that "federal regulatory policy and foreign competition has dramatically altered the marketplace for the U.S. commercial aviation sector."

Technological innovation is "the primary if not the only means of improving industrial productivity; it is the means of developing new businesses that are the

primary source of economic growth" (U.S. Department of Commerce, 1979). "It is the force propelling the American economy forward and a process [that is] inextricably linked to knowledge diffusion" (David, 1986). Studies conducted in the 1960s and early 1970s reveal a positive statistically significant relationship between investment in technological innovation or R&D and the rate of productivity increase and a relatively high marginal rate of return from investment in technological innovation or R&D (Griliches, 1964; Mansfield, 1968; Minasian, 1969; Terleckyj, 1974).

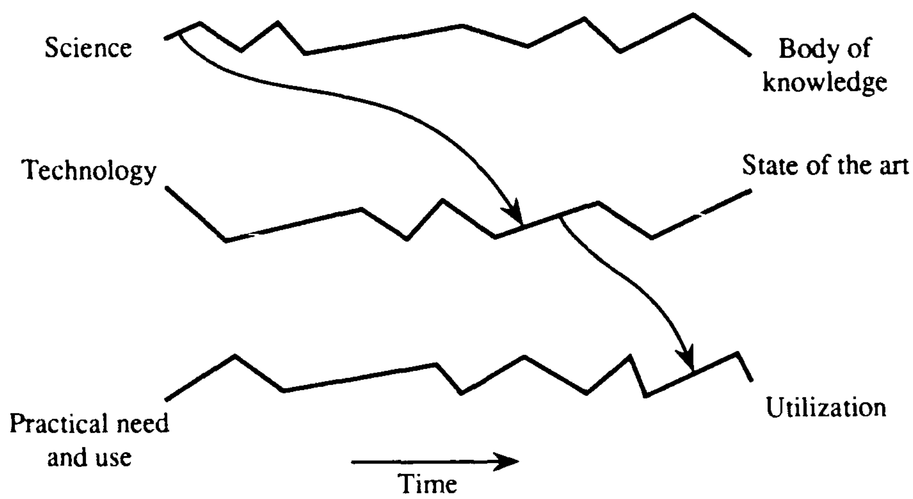
In their treatise, *The Positive Sum Strategy: Harnessing Technology for Economic Growth*, Landau and Rosenberg (1986) describe technological innovation as **the** critical factor in the long-term economic growth of modern industrial societies that functions successfully **only** within a larger social environment that provides an effective combination of incentives and complementary inputs into the innovation process. Technological innovation is a process in which the communication of STI is critical to the success of the enterprise (Fischer, 1980; Solomon and Tornatzky, 1986). "It is a process about which we know little and understand even less" (U.S. Department of Commerce, 1967).

"**Technology**, unlike science, is an extroverted activity; it involves a search for workable solutions to problems. When it finds solutions that are workable and effective, it does not pursue the **why**? very hard. Moreover, the output of technology is a product, process, or service. **Science**, by contrast, is an introverted activity. It studies problems that are usually generated internally by logical discrepancies or internal inconsistencies or by anomalous observations that cannot be accounted for within the present intellectual framework" (Landau and Rosenberg, 1986).

Technology is a process dominated by engineers, as opposed to scientists, which "leads to different philosophies and habits not only about contributing to the technical literature but also to using the technical literature and other sources of information" (Joenk, 1985). Consequently, an understanding of the relationship between science and technology and the information-seeking habits and practices of aerospace engineers is critical to understanding the diffusion of federally funded aerospace R&D.

The Nature of Science and Technology

The relationship between science and technology is often expressed as a continuous process or normal progression from basic research (science) through applied research (technology) to development (utilization). This relationship, which is illustrated in figure 5, is based on the widely held assumption that technology grows out of or is dependent upon science for its development.



Source: Allen (1977) Managing the Flow of Technology

Figure 5. The Progression From Science Through Technology to Development as a Continuous Process.

However, the belief that technological change is somehow based on scientific advance has been challenged in recent years. Technological change has been increasingly seen as the adaption of existing technological concepts in response to demand (Langrish, et al., 1972). Moreover, several years of study that attempted to trace the flow of information from science to technology have produced little empirical evidence to support the relationship (U.S. Department of Defense, 1969 (AKA Project Hindsight);Illinois Institute of Technology, 1968 (AKA Project TRACES). Price (1969), for example, claims:

> The naive picture of technology as applied science simply will not fit the facts. Inventions do not hang like fruits on a scientific tree. In those parts of the history of technology where one feels some confidence, it is quite apparent that most technological advances [are] deriv[ed] immediately from those that precede them.

Substantial evidence exists that refutes the relationship between science and technology. Schmookler (1966) has attempted to show that the variation in inventive activity between different American industries is explicable in terms of the variation in demand, concluding that economic growth determines the rate of inventive activity rather than the reverse. Price (1965), in his investigation of citation patterns in both scientific and technical journals, finds that scientific literature is cumulative and builds upon itself, whereas technical literature is not and does not build upon itself. Citations to previous work are fewer in technical journals and are often the author's own work.

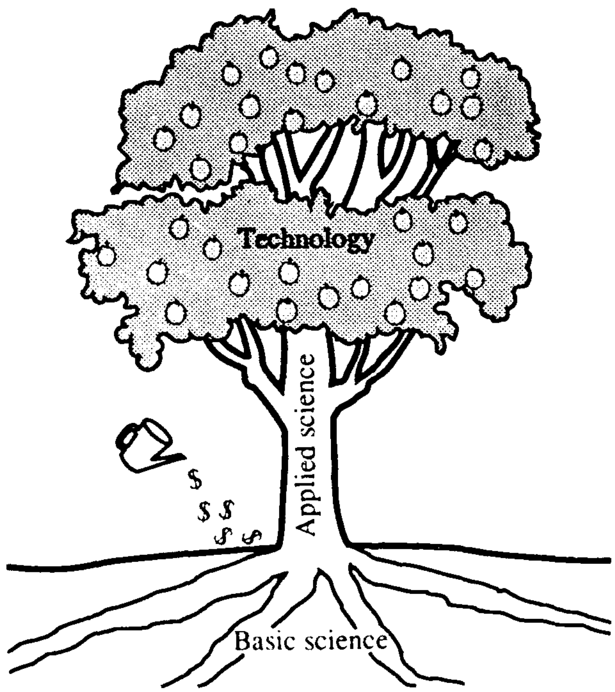
Price (1965) concludes that science and technology progress independently of one another. Technology builds upon its own prior developments and advances in a manner independent of any link with the current scientific frontier and often without any necessity for an understanding of the basic science underlying it.

In summarizing the differences between science and technology, Price (1965) makes the following 12 points. **First**, science has a cumulating, close-knit structure; that is, new knowledge seems to flow from highly related and rather recent pieces of old knowledge, as displayed in the literature. **Second**, this property is what distinguishes science from technology and from humanistic scholarship. **Third**, this property accounts for many known social phenomena in science and also for its surefootedness and high rate of exponential growth. **Fourth**, technology shares with science the same high growth rate, but shows quite complementary social phenomena, particularly in its attitude to the literature. **Fifth**, technology therefore may have a similar, cumulating, close-knit structure to that of science, but it is of the state of the art rather than of the literature. **Sixth**, science and technology each therefore have their own separate cumulating structures. **Seventh**, a direct flow from the research front of science to that of technology, or vice versa, occurs only in special and traumatic cases, since the structures are separate.

Eighth, it is probable that research-front technology is strongly related only to that part of scientific knowledge that has been packed down as part of ambient learning and education, not to research-front science. **Ninth**, research-front science is similarly related only to the ambient technological knowledge of the previous generation of students, not to the research front of the technological state of the art and its innovation. **Tenth**, this reciprocal relation between science and technology, involving the research front of one and the accrued archive of the other, is nevertheless sufficient to keep the two in phase in their separate growths within each otherwise independent cumulation. **Eleventh**, it is therefore naive to regard technology as applied science or

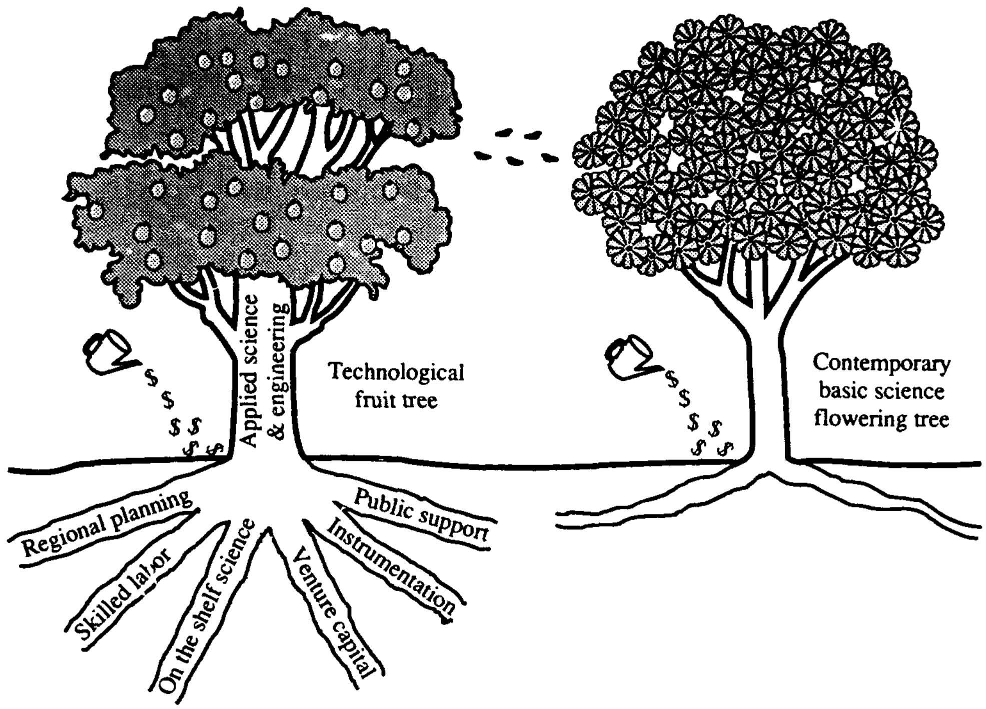
clinical practice as applied medical science. **Twelfth**, because of this, one should be aware of any claims that a particular scientific research is needed for particular technological breakthroughs, and vice versa. Both cumulations can only be supported for their own separate ends.

The single-tree concept, shown in figure 6, is often used to illustrate the relationship between science and technology as a continuous process. Shapley and Roy (1985) argue that such a metaphor is historically inaccurate. In their case for a reorientation of American science policy, they argue that the two-tree concept, which is shown in figure 7, is a more accurate metaphor and is much more useful in developing science policy.



Source: Shapley and Roy (1985) Lost at the Frontier

Figure 6. Science and Technology as a Single Tree.

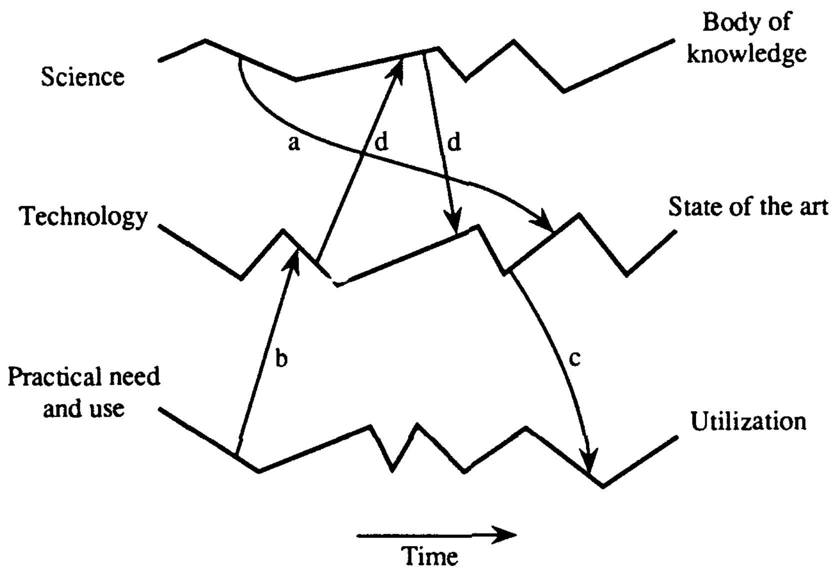


Source: Shapley and Roy (1985) Lost at the Frontier

Figure 7. Science and Technology as Separate Trees.

Shapley and Roy (1985) contend that a normal progression from science to technology does not exist, nor is there direct communication between science and technology. To support their position, they point to the results of innovation research studies, in particular the results of Project Hindsight (1969). Project Hindsight attempted to trace technological advancements resulting from DOD-funded research back to their scientific origins. The study found that, while none of the technological advancements would have been possible without basic science, the link between science and technology was extremely weak. It should be pointed out that the results of Project Hindsight were not universally accepted within the S&T community.

Allen (1977), who studied the transfer of technology and the dissemination of technological information in R&D organizations, finds little evidence to support the relationship between science and technology as a continuous relationship. Allen concludes that the relationship between science and technology, which is depicted in figure 8, is best described as a series of interactions that are based on need rather than on a normal progression.



Source: Allen (1977) Managing the Flow of Technology

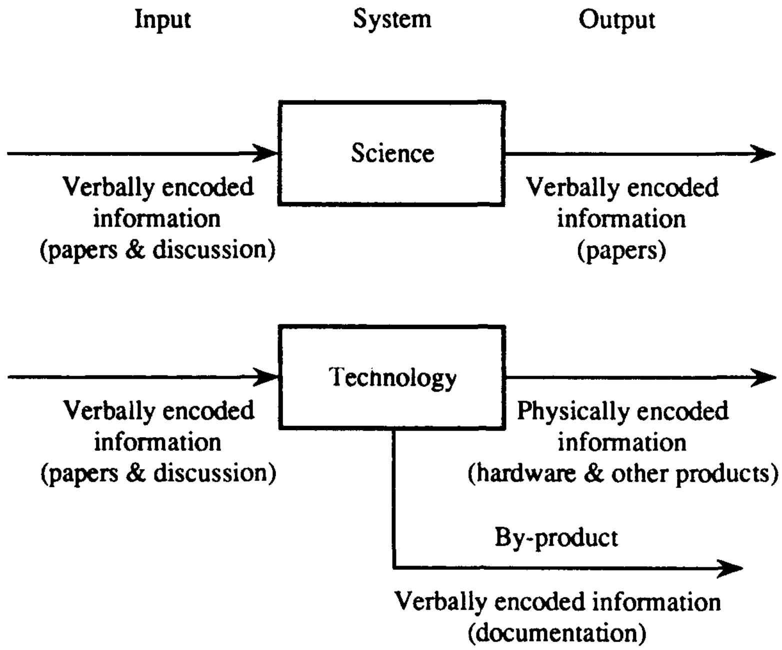
Figure 8. The Progression From Science Through Technology to Development as a Series of Interactions.

According to Allen (1977), (a) the results of science do progress to technology in the sense that some sciences such as physics are more closely connected to technologies such as electronics, but (b) overall a wide variation exists between science and technology. The need for a (c) device, technique, or scientific understanding

influences technology. Technology, in turn, (d) responds to a need and, in doing so, may generate the need for an understanding of certain physical phenomena. A direct communication system between science and technology does not exist to the extent that communication between science and technology is restricted almost completely to that which takes place through the process of education.

Allen (1977) states that the independent nature of science and technology (S&T) and the different functions performed by engineers and scientists directly influence the flow of information in science and technology. Science and technology are ardent consumers of information. Both engineers and scientists require large quantities of information to perform their work. At this level, there is a strong similarity between the information input needs of engineers and scientists. However, the difference between engineers and scientists in terms of information processing becomes apparent upon examination of their outputs (Allen, 1977).

According to Allen (1977), information processing in S&T is depicted in figure 9 in the form of an input-output model. Scientists use information to produce information. From a system standpoint, the input and output, which are both verbal, are compatible. The output from one stage is in a form required for the next stage. Engineers use information to produce some physical change in the world. Engineers consume information, transform it, and produce a product that is information bearing; however, the information is no longer in verbal form. Whereas scientists consume and produce information in the form of human language, engineers transform information from a verbal format to a physically encoded form. Verbal information is produced only as a by-product to document the hardware and other physical products produced.



Source: Allen (1977) Managing the Flow of Technology

Figure 9. Information Processing in Science and Technology.

According to Allen (1977), there is an inherent compatibility between the inputs and outputs of the information-processing system of science. He further states that since both are in a verbal format, the output of one stage is in the format required for the next stage. The problem of supplying information to the scientist becomes a matter of collecting and organizing these outputs and making them accessible. Since science operates for the most part on the premise of free and open access to information, the problem of collecting outputs is made easier.

In technology, however, there is an inherent incompatibility between inputs and outputs. Since outputs are usually in a form different from inputs, they usually cannot serve as inputs for the next stage. Further, the outputs are usually in two parts, one

physically encoded and the other verbally encoded. The verbally encoded part usually cannot serve as input for the next stage because it is a by-product of the process and is itself incomplete (Allen, 1977). Those unacquainted with the development of the hardware or physical product therefore require some human intervention to supplement and interpret the information contained in the documentation (Allen, 1988). Since technology operates to a large extent on the premise of restricted access to information, the problem of collecting the documentation and obtaining the necessary human intervention becomes difficult (Fischer, 1980).

Distinguishing Engineers From Scientists

In their study of the values and career orientation of engineering and science undergraduate students, Krulee and Nadler (1960) found that engineering and science students have certain aspirations in common: to better themselves and to achieve a higher socio-economic status than that of their parents. They report that science students place a higher value on independence and on learning for its own sake, while engineering students are more concerned with success and professional preparation. Many engineering students expect their families to be more important than their careers as a source of satisfaction, but the reverse pattern is more typical for science students.

Krulee and Nadler (1960) also determined that engineering students are less concerned than science students with what one does in a given position and more concerned with the certainty of the rewards to be obtained. They report that, overall, engineering students place less emphasis on independence, career satisfaction, and the inherent interest their specialty holds for them and place more value on success, family life, and avoiding a low-level job. Engineering students appear to be prepared to

sacrifice some of their independence and opportunities for innovation in order to realize their primary objectives. Engineering students are more willing to accept positions that will involve them in complex organizational responsibilities and they assume that success in such positions will depend upon practical knowledge, administrative ability, and human relation skills (Krulee and Nadler, 1960).

In his study of engineers in industry, Ritti (1971) found marked contrast between the work goals of engineers and scientists. Ritti draws the following three conclusions from his study: (1) the goals of engineers in industry are very much in line with meeting schedules, developing products that will be successful in the marketplace, and helping the company expand its activities; (2) while both engineers and scientists desire career development or advancement, for the engineer advancement is tied to activities within the organization, while advancement for the scientist is dependent upon the reputation established outside of the organization; and (3) while publication of results and professional autonomy are clearly valued goals of the Ph.D. scientist, they are clearly the least valued goals of the baccalaureate engineer.

Allen (1988) states that the type of person who is attracted to a career in engineering is fundamentally different from the type of person who pursues a career as a scientist. He writes that "perhaps the single most important difference between the two is the level of education. Engineers are generally educated to the baccalaureate level; some have a master's degree while some have no college degree. The research scientist is usually assumed to have a doctorate. The long, complex process of academic socialization involved in obtaining the Ph.D. is bound to result in persons who differ considerably in their lifeviews." According to Allen, these

differences in values and attitudes toward work will almost certainly be reflected in the behavior of the individual, especially in their use and production of information.

According to Blade (1963), engineers and scientists differ in training, values, and methods of thought. Further, Blade states that the following differences exist in their individual creative processes and in their creative products: (1) scientists are concerned with discovering and explaining nature; engineers use and exploit nature; (2) scientists are searching for theories and principles; engineers seek to develop and make things; (3) scientists are seeking a result for its own ends; engineers are engaged in solving a problem for the practical operating results; and (4) scientists create new unities of thought; engineers invent things and solve problems. Blade states that "this is a different order of creativity."

Finally, communication in engineering and science are fundamentally different. Communication patterns differ because of the fundamental differences between engineering and science and because of the social systems associated with the two disciplines. With one exception, the following characteristics of the social systems as they apply to the engineer and scientist are based on Holmfeld's (1970) investigation of the communication behavior of engineers and scientists.

Engineer

- Contribution is [technical] knowledge used to produce end items or products.
- New and original knowledge is not a requirement.
- Reward is monetary or materialistic and serves as an inducement to continue to make further contributions to technical knowledge.
- Seeking rewards that are not part of the social system of technology is quite proper and also encouraged.

- The value of technical knowledge lies in its value as a commodity of indirect exchange.

- Exchange networks found in the social system of technology are based on end-item products, not knowledge.

- Strong norms against free exchange or open access to knowledge with others outside of the organization exist in the social system of technology.

- Restriction, security classification, and proprietary claims to knowledge characterize the social system of technology.

Scientist

- Contribution is new and original knowledge.

- Reward is social approval in the form of professional [collegial] recognition.

- Recognition is established through publication and claim of discovery.

- A well-developed communication system based on unrestricted access is imperative to recognition and claim of discovery.

- Since recognition and priority of discovery are critical, strong norms against any restriction to free and open communication exist in the social system of science.

- Seeking rewards that are not part of the social system of science in return for scientific contribution is not considered proper within the social system of science.

- Exchange networks commonly referred to as "invisible colleges" exist in the social system of science; in these networks the commodities are knowledge and recognition (Price, 1961; Crane, 1972).

Influence on Information-Seeking Habits and Practices of Engineers

The nature of science and technology and differences between engineers and scientists influence their information-seeking habits, practices, needs, and preferences and have significant implications for planning information services for these two groups

(System Development Corporation, 1966). Taylor (1986), who quotes Brinberg (1980), offers the following characteristics for engineers and scientists: "Unlike scientists, the goal of the engineer is to produce or design a product, process, or system; not to publish and make original contributions to the literature. Engineers, unlike scientists, work within time constraints; they are not interested in theory, source data, and guides to the literature nearly so much as they are in reliable answers to specific questions. Engineers prefer informal sources of information, especially conversations with individuals **within** their organization. Finally, engineers tend to minimize loss rather than maximize gain when seeking information."

Anthony, et al., (1969) suggest that engineers may have psychological traits that predispose them to solve problems alone or with the help of colleagues rather than finding answers in the literature. They further state that "engineers like to solve their own problems. They draw on past experiences, use the trial and error method, and ask colleagues known to be efficient and reliable instead of searching or having someone search the literature for them. They are highly independent and self-reliant without being positively anti-social."

According to Allen (1977), "Engineers read less than scientists, they use literature and libraries less, and seldom use information services which are directly oriented to them. They are more likely to use specific forms of literature such as handbooks, standards, specifications, and technical reports." What an engineer usually wants, according to Cairns and Compton (1970), is "a specific answer, in terms and format that are intelligible to him -- not a collection of documents that he must sift, evaluate, and translate before he can apply them."

Young and Harriott (1979) report that "the engineer's search for information seems to be based more on a need for specific problem solving than around a search for general opportunity. When engineers use the library, it is more in a personal-search mode, generally not involving the professional (but "nontechnical") librarian." Young and Harriot conclude by saying that "when engineers need technical information, they usually use the most accessible sources rather than searching for the highest quality sources. These accessible sources are respected colleagues, vendors, a familiar but possibly outdated text, and internal company [technical] reports. He [the engineer] prefers informal information networks to the more formal search of publicly available and cataloged information."

Evidence exists to support the hypothesis that differences between science and technology and scientists and engineers directly influence information-seeking habits, practices, needs, and preferences. The results of a study conducted by the System Development Corporation (1966) determined that "an individual differs systematically from others in his use of STI" for a variety of reasons. Chief among these are five institutional variables -- "type of researcher, engineer or scientist; type of discipline, basic or applied; stage of project, task, or problem completeness; the kind of organization, fundamentally thought of as academia, government, and industry; and the years of professional work experience."

Studies, such as the work performed by O'Gara (1968), indicate that information-seeking habits, practices, needs, and preferences are influenced by certain sociometric variables. O'Gara found a positive correlation between physical proximity

to an information source and its use. King, et al., (1984) report a positive correlation between the number of visits to a library and proximity of the user.

According to Hardy (1982), two of the major problems in the flow of STI are to create channels by which information is made available and to encourage the use of these channels by those people who need the information that the channels provide. He states that two general models of information seeking relate to the use of STI. One model proposes that an information seeker makes an assessment of the expected benefits and costs of using an information channel and selects an information channel. Hardy refers to this as the **cost-benefit model** of information seeking. According to this model, information seekers assess both costs and benefits of using an information source.

Antecedents to this model are found in economics (Stigler, 1961) and mass communication (Atkin, 1973). Orr (1970) is one of the first authors in the area of information science to propose "channel selection" criteria. According to Orr, "Whatever he [the scientist] opts for, trying observation or the information pool, will depend upon his subjective estimate or perception of the relative likelihood of success in acquiring the desired information by these two alternatives [observation or the information pool] within an acceptable time, on this perception of the relative cost of these alternatives. If he [the scientist] tries the information pool, he recognizes that there is more than one channel through which he may obtain the specific item needed; the same sort of rule will govern the selection of [information] channels. Thus, the scientist makes a decision on which information channel to select on the basis of both cost and expected outcome."

Hardy's (1982) **second** model is the **least-effort model** of information seeking. It asserts that individuals who look for information do so in a way that the least amount of effort is expended in the process. This is accomplished by choosing the information source that has the least psychological and financial cost in its use. According to this model, information seekers will choose a source in order to minimize cost regardless of the quality of the information they expect to obtain (Hardy, 1982).

Gerstberger and Allen (1968), in their study of engineers and their choice of an information channel, note the following:

> Engineers, in selecting among information channels, act in a manner which is intended not to maximize gain, but rather to minimize loss. The loss to be minimized is the cost in terms of effort, either physical or psychological, which must be expended in order to gain access to an information channel.

Their behavior appears to follow a "law of least effort" (Zipf, 1949). According to this law, individuals, when choosing among several paths to a goal, will base their decision upon the single criterion of "least average rate of probable work." According to Gerstberger and Allen, engineers appear to be governed or influenced by a principle closely related to this law. They attempt to minimize effort in terms of work required to gain access to an information channel. Gerstberger and Allen reached the following conclusions:

1. Accessibility is the single most important determinant of the overall extent to which an information channel or source is used by an engineer.

2. Both accessibility and perceived technical quality influence the choice of the first source.

3. The perception of accessibility is influenced by experience. The more experience engineers have with an information channel or source, the more accessible they perceive it to be.

Gerstberger and Allen (1968) conclude their discussion by stating that "any assumption that engineers act in accord with a simple instrumental learning model in which they turn most frequently to those information channels which reward them most often should now clearly be laid to rest." Rosenberg's (1967) findings also support the conclusions by Gerstberger and Allen that accessibility almost exclusively determines the frequency of use of information channels. Rosenberg concludes that researchers minimize the cost of obtaining information while sacrificing the quality of the information received.

In his study of the *Factors Related to the Use of Technical Information in Engineering Problem Solving*, Kaufman (1983) reports that engineers rated **technical quality** or **reliability** followed by **relevance** as the criteria used in choosing the most useful information source. However, **accessibility** appears to be used most often for selecting an information source **even if that source** proved to be the least useful.

In his review of the cost-benefit and least-effort models, Hardy (1982) assumes that information seekers assess the cost and benefits of alternative information sources. He says that "information seekers are assumed to place different weights on the costs and benefits of an information source. They do not seek to minimize cost. They weigh cost as being the most important criterion in selecting an information source." Hardy concludes that "information seekers do evaluate information sources on the basis of their costs and benefits, not cost alone as Allen (1977) maintains. The majority of weight in their decision does go to cost. Contrary to Orr's (1970) expectations, the quality of the information obtained is less important than its accessibility."

THE INFORMATION-SEEKING HABITS AND PRACTICES OF ENGINEERS AND SCIENTISTS

Studies specifically concerned with the information-seeking habits and practices of engineers and scientists were reviewed to further develop the conceptual framework for the study. Research studies deemed significant to this topic are listed in the "Overview of Engineering STI Studies" and are discussed in some detail. Although not comprehensive, data from these studies are used to further develop the concept of "different" information-seeking habits and practices for engineers and scientists.

Some other studies are worthy of mention. Dissertations by Halperin (1986), Kasperson (1976), and Mondschein (1988) purport to have studied "scientists and engineers" when, in fact, it is unclear which of the two groups were studied. The two groups are not the same. According to Allen (1977), "The argument that scientist is a more generic term merely evades the fundamental issue. The practice of lumping the two groups [engineers and scientists] together is self-defeating in information [production, transfer, and] use studies because confusion over the characteristics of the sample has led to what appears to be conflicting results and to a greater difficulty in developing normative measures for improving information systems in either science or technology." Seiss (1982), who supports Allen's position, states that "the terms engineer and scientists are not synonymous and that the difference in work environment and personal/professional goals between the engineer and scientist proves to be an important factor in determining their information-seeking practices."

David's (1979) study, conducted for the World Federation of Engineering Organizations, represents an analysis of the engineer's role and need for STI. Wilkin's

(1981) work is concerned with the information needs of engineers in a variety of specialties. Raitt's (1984) study focuses on the information-seeking and use habits of engineers and scientists in selected European aerospace research establishments. Picken's (1988) study is concerned with the organization and use of aerospace library and information services in the United Kingdom.

OVERVIEW OF ENGINEERING STI STUDIES

Year	Principal Investigator	Research Method	Population	Sample Frame	Sample Design	Sample Size	Percentage Response Rate (number responding)	Description
1954	Herner	Structured interview	All scientific and technical personnel at Johns Hopkins	Unknown	Unknown	600	100	Survey to determine the information-gathering methods of scientific and technical personnel at Johns Hopkins
1970	Rosenbloom and Wolek	Self-administered questionnaire	Members of 5 industrial R&D organizations	2 430	Census	2 430	71 (1 735)	Survey to determine how engineers and scientists in industrial research and development organizations acquire STI
			Members of 4 IEEE interest groups	Unknown	Probability	Unknown	Unknown (1 034)	
1977	Allen	Record analysis Self-administered questionnaire	Unknown	Unknown	Unknown	Unknown	Unknown (1 153)	Survey to determine technology transfer and the dissemination of technological information in research and development organizations
1980	Kremer	Self-administered questionnaire	All design engineers at one engineering design firm	73	Census	73	82 (60)	Survey to identify and evaluate the information channels used by engineers in a design company
1981	Shuchman	Structured interview Self-administered questionnaire	Engineers in 89 R&D and non-R&D organizations	14 797	Probability	3 371	39 (1 315)	Survey to determine information used and production in engineering
1983	Kaufman	Self-administered questionnaire	Engineers in six technology-based organizations	147	Census	147	100 (147)	Survey to determine the use of technical information in technical problem solving

Herner

Herner's (1954) is one of the first "user" studies that is specifically concerned with "differences" in information-seeking habits and practices. He reports significant differences in terms of researchers performing "basic and applied" research, researchers performing "academic and industry" type duties, and their information-seeking habits and practices. Herner says that researchers performing "basic or academic" duties make greater use of formal information channels or sources, depend mainly on the library for their published material, and maintain a significant number of contacts outside of the organization.

Researchers performing "applied or industry" duties make greater use of informal channels or sources, depend on their personal collections of information and colleagues for information, make significantly less use of the library than do their counterparts, and maintain fewer contacts outside of the organization. Applied or industry researchers make substantial use of handbooks, standards, and technical reports. They also read less and do less of their reading in the library than do their counterparts (Herner, 1954).

Rosenbloom and Wolek

Rosenbloom and Wolek (1970) conducted one of the first "large-scale" industry studies that was specifically concerned with the flow of STI within R&D organizations. They report three significant and fundamental differences between engineers and scientists: (1) engineers tend to make substantially greater use of information sources **within** the organization than do scientists; (2) scientists make considerably greater use of the professional (formal) literature than do engineers; and (3) scientists are more

likely than engineers to acquire information as a consequence of activities directed toward general competence rather than a specific task.

In terms of interpersonal communication, the engineers in the Rosenbloom and Wolek (1970) study recorded a higher incidence of interpersonal communication with people in other parts of their own corporation, whereas scientists recorded a greater incidence of interpersonal communication with individuals employed outside their own corporation. When using the literature, the engineers tend to consult in-house technical reports or trade publications, while the scientists tend to make greater use of the professional [formal] literature.

Rosenbloom and Wolek (1970) report certain similarities between engineers and scientists. The propensity to use alternative types of technical information sources is related to the purposes that will give meaning to the use of that information. Work that has a professional focus draws heavily on sources of information external to the user's organization. Work that has an operational focus seldom draws on external sources, relying heavily on information that is available within the employing organization. Those engineers and scientists engaged in professional work commonly emphasize the simplicity, precision, and analytical or empirical rigor of the information source. Conversely, those engineers and scientists engaged in operational work typically emphasize the value of communication with others who understand and are experienced in the same real context of work.

Allen

Allen's (1977) study of technology transfer and the dissemination of technological information within the R&D organization is the result of a 10-year

investigation. Allen describes the study, which began as a "user study," as a systems-level approach to the problem of communication in technology. Allen's work is considered by many information professionals to be the seminal work on the flow of technical information within R&D organizations.

Allen (1977) was among the first to produce evidence supporting different information-seeking habits and practices for engineers and scientists. These differences, Allen notes, lead to different philosophies and habits regarding the use of the technical literature and other sources of information by engineers. The most significant of Allen's findings is the relative lack of importance of the technical literature in terms of generating new ideas and in problem definition, the importance of personal contacts and discussions between engineers, the existence of technological "gatekeepers," and the importance of the technical report. Allen states that "the unpublished report is the single most important informal literature source; it is the principal written vehicle for transferring information in technology."

<u>Kremer</u>

Kremer's (1980) study was undertaken to gain insight on how technical information flows through formal and informal channels among engineers in a design company. The engineers in her study are not involved in R&D. Kremer's findings are summarized as follows.

In terms of information habits, personal files are the most frequently consulted source for needed information. The reason given most frequently to search for information is problem solving; colleagues within the company are contacted first for needed information, followed by colleagues outside of the company. In terms of the tech-

nical literature, handbooks are considered most important, followed by standards and specifications. Libraries are not considered to be important sources of information and are used infrequently by company engineers.

Regardless of age and work experience, design engineers demonstrate a decided preference for internal sources of information. The perceived accessibility, ease of use, technical quality, and amount of experience a design engineer has had with an information source strongly influence the selection of an information source. Technological gatekeepers were found to exist among design engineers; they are high technical performers and a high percentage are first line supervisors.

<u>**Shuchman**</u>

Shuchman's (1981) study is a broad-based investigation of information transfer in engineering. The respondents represented 14 industries and the following major disciplines: civil, electrical, mechanical, industrial, chemical and environmental, and aeronautical. Seven percent, or 93 respondents, were aeronautical engineers. The engineers in Shuchman's study, regardless of discipline, display a strong preference for informal sources of information. Further, these engineers rarely find all the information they need for solving technical problems in one source; the major difficulty engineers encounter in finding the information they need to do their job is identifying a specific piece of missing data and then learning who has it.

In terms of information sources and solving technical problems, Shuchman (1981) reports that engineers first consult their personal store of technical information, followed in order by informal discussions with colleagues, discussions with supervisors, use of internal technical reports, and contact with a "key" person in the organization

who usually knows where the needed information may be located. Shuchman states that technical libraries and librarians are used by a small proportion of the engineering profession.

In general, Shuchman (1981) states engineers do not regard information technology as an important adjunct to the process of producing, transferring, and using information. While technological gatekeepers appear to exist across the broad range of engineering disciplines, their function and significance is not uniform; considering the totality of engineering, gatekeepers account for only a small part of the information transfer process.

Kaufman

Kaufman's (1983) study is concerned with the factors relating to the use of technical information by engineers in problem solving. The study reports that, in terms of information sources, engineers consult their personal collections first, followed by colleagues and then by formal literature sources. In terms of formal literature sources used for technical problem solving, engineers use technical reports, followed in order by books, monographs, and technical handbooks.

Most sources of information, according to Kaufman (1983), are found primarily through an intentional search of written information, followed by personal knowledge and then by asking someone. The study purports that the criteria used in selecting all information sources, in descending order of frequency, are accessibility, familiarity or experience, technical quality, relevance, comprehensiveness, ease of use, and expense. The various information sources are used by engineers for specific purposes. Librarians and information specialists are primarily utilized to find leads to information

sources. On-line computer searches are used primarily to define the problem. The technical literature is used primarily to learn techniques applicable to dealing with the problem. Personal experience is used primarily to find solutions to the problem.

Kaufman (1983) reports that the criteria used in selecting the most useful information sources, in descending order of frequency, are technical quality or reliability, relevance, accessibility, familiarity or experience, comprehensiveness, ease of use, and expense. In terms of the effectiveness, efficiency, and usefulness of the various information sources, personal experience is rated as the most effective in accomplishing the purpose for which it is used; librarians and information specialists receive the lowest rating for efficiency and effectiveness. Most engineers use several different types of information sources in problem solving; however, engineers do depend on their personal experience more often than on any single specific information source.

THE TECHNICAL COMMUNICATIONS PRACTICES OF U.S. AEROSPACE ENGINEERS AND SCIENTISTS

An exploratory study (Pinelli, et al., 1989) was conducted that investigated the technical communications practices of U.S. aerospace engineers and scientists. The study, which utilized survey research in the form of a self-administered mail questionnaire, had a twofold purpose: (1) to gather baseline data regarding several aspects of technical communications in aerospace and (2) to develop and validate questions that could be used in *this* study, which is concerned with understanding the role of the U.S. government technical report in the diffusion of knowledge resulting from federally funded aerospace R&D.

The exploratory study had five specific objectives: first, to solicit the opinions of aerospace engineers and scientists regarding the importance of technical communications to their profession; second, to determine the use and production of technical communications by aerospace engineers and scientists; third, to seek their views about the appropriate content of an undergraduate course in technical communications; fourth, to determine aerospace engineers' and scientists' use of libraries, technical information centers, and on-line data bases; and fifth, to determine the use and importance of computer and information technology to them.

Data were collected by means of a self-administered mail questionnaire that was pretested at the NASA Ames Research Center and the McDonnell Douglas Corporation in St. Louis. Members of the American Institute of Aeronautics and Astronautics (AIAA) comprised the study population. The sample frame consisted of approximately 25 000 AIAA members in the United States with either academic, government, or industry affiliations. Random sampling was used to select 2000 members from the sample frame to participate in the exploratory study. Six hundred and six (606) usable questionnaires (30-percent response rate) were received by the established cutoff date.

The study spanned the period from July 1988 to November 1988. The questionnaire used in the study contained 35 questions: 25 questions concerned technical communications in aeronautics, 8 questions concerned demographic information about the survey respondents, and 2 were open-ended questions.

Time Devoted to Communicating Technical Information

The aerospace engineers and scientists in the exploratory study (Pinelli, et al., 1989) spend an average of 13.95 hours per week communicating technical information

to others (table 5). Based on a 40-hour work week, they spend approximately 35 percent of their work week communicating technical information to others (Pinelli, et al., 1989). Respondents to the Davis (1977) study spend approximately 25 percent of their time communicating technical communications to others.

Table 5. Time Spent Communicating Technical Information to Others

Hours per week [a]	Number	Percentage
5 or less	102	17.1
6 to 10	189	31.7
11 to 20	237	39.8
21 or more	68	11.4
	596	100.0

[a] Mean = 13.95 hours.

The aerospace engineers and scientists in the exploratory study (Pinelli, et al., 1989) spend approximately 13 hours a week working with technical communications received from others (table 6). In a 40-hour work week, they spend approximately 31 percent of their week with such work. Respondents to the Davis (1977) study spend about 30 percent of their time working with technical communications received from others. Considering both the time spent working on the preparation of technical information and the time spent working with technical information received from others, technical communication takes up approximately 66 percent of the 40-hour work week for the U.S. aerospace engineers and scientists in the exploratory study.

Table 6. Time Spent Working With Technical Communications Received From Others

Hours per week[a]	Number	Percentage
5 or less	126	21.1
6 to 10	222	37.2
11 to 20	197	33.0
21 or more	52	8.7
	597	100.0

[a] Mean = 12.57 hours.

The Use and Production of Technical Information

Respondents produce a variety of technical information products (table 7).

Table 7. Technical Information Products Produced

Technical information product	Percent of respondents producing –				Average
	None	1 - 5	6 - 10	11 and above	
Letters	15.0	22.7	22.8	39.5	22.2
Memos	8.6	14.9	19.1	57.4	28.8
Technical reports – government	60.9	31.7	5.6	1.8	1.6
Technical reports – other	57.1	34.2	6.5	2.2	1.9
Proposals	47.4	46.4	4.2	2.0	1.8
Technical manuals	84.9	13.9	1.2	0.0	0.3
Computer program documentation	70.0	24.6	3.6	1.8	1.3
Journal articles	80.0	19.4	0.4	0.2	0.4
Conference-meeting papers	62.8	33.9	1.8	1.5	1.1
Trade-promotional literature	93.0	5.6	0.9	0.5	0.3
Press releases	90.0	9.3	0.2	0.5	0.3
Drawings-specifications	71.8	17.8	3.3	7.1	3.2
Speeches	54.0	35.0	7.5	3.5	2.2
Audiovisual materials	30.1	36.2	17.4	16.3	6.6

Most Frequently Produced Technical Information Products 6-month production	**Least Frequently Produced Technical Information Products** 6-month production
Memos	Trade-promotional literature
Letters	Press releases
Audiovisual materials	Technical manuals
Drawings-specifications	Journal articles
Speeches	Conference-meeting papers

Based on average production, the U.S. aerospace engineers and scientists in the exploratory study produce approximately 29 memos, 22 letters, 7 audiovisual (AV) materials, 3 drawings-specifications, and 2 speeches. Other technical information products are produced less frequently. Based on average production, respondents produce 1.1 conference-meeting papers; 0.3 trade-promotional literature, press releases, and technical manuals; and 0.4 journal articles in a 6-month period. Approximately 43 and 40 percent of the respondents, respectively, produce one or more technical reports and government technical reports during the 6-month period.

A one-way ANOVA (analysis of variance) was used to compare respondents with academic, government, and industry organizational affiliations with their production of technical information products. Academic respondents produce significantly more letters, proposals, and journal articles than do respondents in other groups. Industry respondents produce significantly more technical reports than do respondents in the other groups. NASA respondents produce significantly more government technical reports than do respondents in the other groups (Pinelli, et al., 1989).

Respondents use a variety of technical information products (table 8).

Table 8. Technical Information Products Used

Technical information product	Percent of respondents using –				Average
	None	1 - 5	6 - 10	11 and above	
Letters	18.7	30.4	20.5	30.4	16.7
Memos	10.3	27.7	17.5	44.5	24.3
Technical reports – government	35.3	44.8	12.9	7.0	4.2
Technical reports – other	34.5	46.3	11.0	8.2	4.5
Proposals	57.2	38.2	3.8	0.8	1.4
Technical manuals	60.9	31.1	4.8	3.2	2.2
Computer program documentation	55.7	34.5	5.3	4.5	3.0
Journal articles	34.9	36.8	14.9	13.4	6.7
Conference-meeting papers	43.8	39.8	10.0	6.4	4.3
Trade-promotional literature	54.1	27.6	9.1	9.2	5.7
Drawings-specifications	56.3	23.7	8.5	11.5	7.9
Audiovisual materials	47.0	33.4	11.9	7.7	5.5

Most Frequently Used Technical Information Products 1-month use	**Least Frequently Used Technical Information Products** 1-month use
Memos	Proposals
Letters	Technical manuals
Drawings-specifications	Computer program documentation
Journal articles	Government technical reports
Trade-promotional literature	Conference-meeting papers

Based on average use, the U.S. aerospace engineers and scientists in the exploratory study use approximately 24 memos, 17 letters, 8 drawings-specifications, 7 journal articles, and 6 pieces of trade-promotional literature in a 1-month period. Other technical information products are used less frequently. Based on average use, respondents use 1.4 proposals, 2.2 technical manuals, 3.0 pieces computer program

documentation, 4.2 government technical reports, and 4.3 conference-meeting papers. Approximately 65 percent of the respondents use one or more technical reports and government technical reports during a 1-month period.

A one-way ANOVA was used to compare respondents with academic, government, and industry organizational affiliations with their use of technical information products. NASA respondents use significantly more government technical reports and AV materials than do the respondents in the other groups.

Respondents produce a variety of technical information (table 9).

Table 9. Types of Technical Information Produced

Type of technical information	Respondents	
	No.	%
Scientific and technical information	555	92.2
Experimental techniques	269	44.7
Codes of standards and practices	126	20.9
Design procedures and methods	282	47.0
Computer programs	344	57.1
Government rules and regulations	92	15.4
In-house technical data	511	84.9
Product and performance characteristics	350	58.2
Economic information	164	27.2
Technical specifications	359	59.6
Patents	109	18.1

Most Frequently Produced Technical Information
6-month use

S&T information
In-house technical data
Technical specifications
Product and performance characteristics
Computer programs

Least Frequently Produced Technical Information
6-month use

Government rules and regulations
Patents
Codes of standards and practices
Economic information
Experimental techniques

Chi-square cross tabulations were used to compare respondents' organizational affiliation with their production of specific types of technical information. Academic and NASA respondents are more likely than expected to produce experimental techniques. Academic and NASA respondents are less likely than expected to produce codes of standards and practices. Industry respondents are more likely and academic and NASA respondents less likely than expected to produce product and performance characteristics. Academic and NASA respondents are less likely than expected to produce economic information.

Respondents use a variety of technical information (table 10).

Table 10. Types of Technical Information Used

Type of technical information	Respondents	
	No.	%
Scientific and technical information	584	97.0
Experimental techniques	363	60.4
Codes of standards and practices	287	47.8
Design procedures and methods	336	55.9
Computer programs	486	80.7
Government rules and regulations	432	71.9
In-house technical data	545	90.5
Product and performance characteristics	435	72.3
Economic information	215	35.8
Technical specifications	463	76.9
Patents	85	14.1

Most Frequently Used Technical Information
6-month use

S&T information
In-house technical data
Computer programs
Technical specifications
Product and performance characteristics

Least Frequently Used Technical Information
6-month use

Patents
Economic information
Codes of standards and practices
Design procedures and methods
Experimental techniques

Data on the types of technical information produced and used by U.S. aerospace engineers and scientists in the exploratory study (Pinelli, et al., 1989) were compared with the data reported for the aeronautical engineers in Shuchman's (1981) study. The five types of technical information most frequently produced and used are presented for comparison.

Most Frequently Produced Technical Information

Shuchman (1981)	Pinelli, et al., (1989)
In-house technical data	S&T information
Physical data	In-house technical data
S&T information	Technical specifications
Design methods	Product and performance characteristics
Computer programs	Computer programs

Most Frequently Used Technical Information

Shuchman (1981)	Pinelli, et al., (1989)
S&T information	S&T information
In-house technical data	In-house technical data
Computer programs	Computer programs
Physical data	Technical specifications
Design methods	Product and performance characteristics

The different sample sizes and the research designs for the Shuchman and Pinelli, et al., studies affect the extent to which a valid comparison can be made between the two data sets. Nevertheless, to the extent that such a comparison is valid, the types of technical information produced in both studies compare reasonably well. There is, however, a much better fit between the types of technical information used.

Technical Information and Problem Solving

Aerospace engineers and scientists in the exploratory study (Pinelli, et al., 1989) use a variety of sources of technical information when solving technical problems (table 11). The sources of technical information used by aerospace engineers and

Table 11. Information Sources Used to Solve Technical Problems

Source	Percent of respondents
1. Personal knowledge	88.7
2. Informal discussion with colleagues	77.2
3. Discussions with experts within the organization	69.5
4. Discussions with supervisor	45.1
5. Textbooks	39.6
6. Technical reports	35.4
7. Journals and conference-meeting papers	35.2
8. Handbooks and standards	34.5
9. Government technical reports	33.5
10. Discussions with experts outside of the organization	25.5
11. Librarians and technical information specialists	14.1
12. Technical information sources such as on-line data bases	8.2

scientists in the exploratory study to solve technical problems compare favorably with the findings of previous studies. Like engineers in general, U.S. aerospace engineers and scientists display the same preference for using personal knowledge, personal contacts, and informal sources of information.

In an attempt to validate the findings, the sources of technical information used by aerospace engineers and scientists in the exploratory study were compared with the sources used by the engineers in Shuchman's (1981) study, *Information Transfer in Engineering*. With minor exceptions, the aerospace engineers and scientists in the

Information Sources Used to Solve Technical Problems

Source	Percent of respondents
1. Consulted personal store of technical information	93
2. Informal discussion with colleagues	87
3. Discussed problem with supervisor	61
4. Consulted internal technical reports	50
5. Consulted key person in firm who usually knows new information	38
6. Consulted library sources (e.g., technical journals, conference proceedings)	35
7. Consulted outside consultant	33
8. Used electronic data bases	20
9. Consulted librarian or technical information specialist	14
10. No pattern in problem solving	5

Source: Shuchman (1981) Information Transfer in Engineering

exploratory study seek information from sources similar to the sources used by engineers in Shuchman's study. Both groups begin with what Allen (1977) calls an "informal personal search for information followed by the use of formal information sources. Having completed these steps, engineers turn to librarians and library services for assistance."

Use of Libraries, Technical Information Centers, and On-Line Data Bases

Ninety-four percent of the respondents indicate that they use a library or technical information center (table 12). The frequency rates vary among respondents, with 27 percent using a library or technical information center one or more times a week (Pinelli, et al., 1989).

Table 12. Use of a Library or Technical Information Center

Use rate	Respondents	
	No.	%
Daily	12	2.0
Two to six times a week	60	10.0
Once a week	90	15.0
Two to three times a month	116	19.2
Once a month	102	16.9
Less than once a month	186	30.9
Do not use	36	6.0
	602	100.0

Approximately 63 percent of the respondents use a library or technical information center one or more times a month, while approximately 31 percent use a library or technical information center less than once a month. The use of libraries and technical information centers by aerospace engineers and scientists in the exploratory study compares favorably with the use rate of libraries and technical information centers by engineers reported in previous studies.

Less than half, or 44.1 percent of the survey respondents, use on-line data bases (table 13). Of those survey respondents who use on-line data bases, 23 percent do all or most of their own searches (table 14). Approximately 65 percent use an intermediary to do most or all of their searches, while about 12 percent do half the searches themsevles and use an intermediary for the other half of the searches (Pinelli, et al., 1989).

Table 13. Use of Electronic Data Bases

Use	Number	Percentage
Yes	265	44.1
No	336	55.9
	601	100.0

Table 14. How Electronic Data Bases Are Searched

How searched	Number	Percentage
Do **all** searches myself	18	6.9
Do **most** searches myself	42	16.1
Do **half** by myself and **half** through an intermediary (e.g., librarian)	32	12.3
Do **most** searches through an intermediary (e.g., librarian)	92	35.2
Do **all** searches through an intermediary	77	29.5
	261	100.0

Use of Information Technology

Aerospace engineers and scientists in the exploratory study use a variety of information technologies to communicate technical information (table 15). The percentage of "I already use it" responses ranges from 84.3 percent (fax or telex) to 6.1 percent (laser disc, videodisc, or CD-ROM) (Pinelli, et al., 1989).

Table 15. Use, Nonuse, and Potential Use of Information Technologies

Information technology	I already use it		I don't use it, but may in the future		I don't use it, and doubt if I will	
	No.	%	No.	%	No.	%
Audiotapes and cassettes	118	20.3	172	29.6	292	50.1
Motion picture film	118	20.5	142	24.7	315	54.8
Videotape	275	46.5	234	39.6	82	13.9
Desktop-electronic publishing	272	46.5	243	41.5	70	12.0
Floppy disks	441	74.5	112	18.9	39	6.6
Computer cassette-cartridge tapes	129	22.7	222	39.0	218	38.3
Electronic mail	274	46.6	255	43.4	59	10.0
Electronic bulletin boards	148	25.7	308	53.6	119	20.7
Fax or telex	501	84.3	64	10.8	29	4.9
Electronic data bases	290	50.3	233	40.4	54	9.3
Videoconferencing	95	16.3	363	62.4	124	21.3
Teleconferencing	344	58.7	182	31.1	60	10.2
Micrographics and microforms	100	18.0	245	44.0	212	38.0
Laser disc, videodisc, or CD-ROM	35	6.1	370	64.9	165	29.0
Electronic networks	185	32.2	303	52.8	86	15.0

The most frequently used information technologies, in descending order of use, for communicating technical information are listed below.

Information Technology	Percentage Use
Fax or Telex	84.3
Floppy disks	74.5
Teleconferencing	58.7
Electronic data bases	50.3
Electronic mail	46.6
Videotape	46.5
Desktop-electronic publishing	46.5

A further look at table 15 reveals several information technologies for which a considerable number of "I don't use it, and doubt if I will" responses were recorded. The percentages of these responses range from a high of 54.8 percent (motion picture film) to a low of 4.9 percent (fax or telex). The five information technologies receiving the highest percentage of "I don't use, and doubt if I will" responses appear below in descending order of nonuse.

Information Technology	Percentage Nonuse
Motion picture film	54.8
Audiotapes and cassettes	50.1
Computer cassette-cartridge tapes	38.3
Micrographics and microforms	38.0
Laser disc, videodisc, or CD-ROM	29.0

Table 15 also indicates several information technologies for which a considerable percentage of "I don't use it, but may in the future" responses were recorded. The percentages of these responses range from a high of 64.9 percent (laser disc, videodisc, or CD-ROM) to a low of 10.8 percent (fax or telex). The five information technologies receiving the highest percentage of "I don't use it, but may in the future" responses appear below in descending order of potential use.

Information Technology	Percentage Potential Use
Laser disc, videodisc, or CD-ROM	64.9
Videoconferencing	62.4
Electronic bulletin boards	53.6
Electronic networks	52.8
Micrographics and microforms	44.0

In Shuchman's (1981) study, respondents were asked to indicate the use, nonuse, and potential usefulness of 21 computer and information technologies. These 21 technologies are arranged into the following four groups: computer devices, information transmission, recorded and prerecorded, and advanced technology. The

Group 1
<u>Computer Devices</u>

Computations
Keyboard
Line printer
Accessing data banks
Video displays
Computer-aided instruction
Line and graphics printers

Group 2
<u>Information Transmission</u>

Fast facsimile
Teleconferencing
Audio conference calls

Group 3
<u>Recorded and Prerecorded</u>

Audiocassettes
Audio with high-speed playback
Motion picture film and video tape
Videodiscs

Group 4
<u>Advanced Technology</u>

Video telephone
Video closed-circuit TV
Audio recognition

following six engineering disciplines were represented in Shuchman's (1981) study: aeronautical, civil, chemical and environmental, electrical, industrial, and mechanical. Comparisons were made by Shuchman among the four computer and information technology groups and the six engineering disciplines in terms of use, nonuse, and potential usefulness.

Computer and information technologies in Group 1 were used by half of the engineers in Shuchman's (1981) study. Almost two-thirds (62 percent) of the aeronautical engineers used Group 1 technologies. Next to electrical engineers (15 percent), aeronautical engineers had the lowest "nonuse" (16 percent) of Group 1

technologies of the six engineering disciplines, while 22 percent of those aeronautical engineers surveyed indicated that Group 1 technologies had "potential usefulness."

A larger-than-average number of aeronautical engineers (57 percent) used Group 2 technologies. Of the six engineering disciplines, aeronautical engineers had the lowest nonuse (17 percent) of Group 2 technologies, while 26 percent of those aeronautical engineers surveyed indicated that Group 2 technologies had potential usefulness.

Group 3 technologies represent both traditional and evolving technologies. Slightly more than half of those engineers who responded used slides and viewgraphs, while only 4 percent of the respondents used high-speed video. Slightly more than one-third (35 percent) of the aeronautical engineers used Group 3 technologies. Of the six engineering disciplines, aeronautical engineers had the lowest nonuse (34 percent) of the Group 3 technologies and 31 percent of those aeronautical engineers surveyed indicated that Group 3 technologies had potential usefulness.

Group 4 technologies, which contain some of the "newer" developments in computer and information technology, were used by a small percentage of the respondents. Aeronautical and mechanical engineers represented the highest percentages of Group 4 technology users. Of the six engineering disciplines, aeronautical engineers had the lowest nonuse (52 percent) of the Group 4 technologies and 40 percent of those aeronautical engineers surveyed indicated that Group 4 technologies had potential usefulness.

The aerospace engineers and scientists in the exploratory study make considerable use of computer and information technology. Their use, nonuse, and

potential use responses compare quite favorably to the responses of the aeronautical engineers in Shuchman's (1981) study.

REVIEW OF THE RELEVANT RESEARCH

To further develop the conceptual framework for the study, literature relevant to the information-seeking habits and practices of engineers and to the diffusion of federally funded aerospace R&D is grouped according to the following four topics:

- o Knowledge diffusion and technological innovation
- o Knowledge diffusion, technological innovation, and government policy
- o Knowledge diffusion, technological innovation, and STI
- o Knowledge diffusion, technological innovation, and federally funded aerospace R&D

Selected findings, recommendations, and contributions addressing these topics are summarized in tables 16-19. This material sets the general tone of research and literature related to the information-seeking habits and practices of engineers, STI, technological innovation, and knowledge diffusion. Although comprehensive, the list is not exhaustive.

Tables 16-19 indicate that numerous factors contribute to the economic growth, prosperity, and performance of a nation. Studies performed by economists, such as Mansfield (1968,1982), reveal that from 40 to 90 percent of the increase in economic growth can be attributed to technological innovation, gains in knowledge, diffusion of technology, or similar innovation-related factors. Although the precise amount of their contributions to economic growth, prosperity, and performance remain unresolved, the

consensus is that technological innovation has contributed significantly to the economic growth of post-World War II United States in general (Nelson 1982) and the U.S. commercial aviation industry in particular (Mowery, 1985). Economists, such as David (1986), point out that "technological innovation is the primary, if not the only means of improving industrial productivity. It is the force propelling the American economy forward and a process [that is] inextricably linked to knowledge transfer and diffusion."

Table 16 indicates that knowledge diffusion is the process by which a [technological] innovation is communicated through certain channels over time among the members of a social system (Rogers, 1983). Rogers further states that "diffusion is a special type of communication, in which the messages are concerned with new ideas. In the case of technology, the newness of the idea brings with it a high degree of technical **uncertainty**. The **newer the idea**, the greater the amount of **uncertainty**." In technology, as elsewhere, information is used to reduce or moderate uncertainty. Thus, according to Rogers, it is useful to conceptualize technological innovation and knowledge diffusion within a framework based on knowledge or information diffusion and uncertainty.

Table 18 contains a small sampling of the literature concerned with knowledge diffusion, technological innovation, and STI. The ability of engineers and scientists to identify, acquire, and utilize scientific and technical information (STI) is of paramount importance to the efficiency of technological innovation and the R&D process. Testimony to the central role of STI in the R&D process is found in numerous studies. These studies show, among other things, that engineers and scientists, and aerospace engineers and scientists in particular, devote more time, on the average, to the

communication of technical information than to any other scientific or technical activity (Fischer, 1980; Pinelli, et al., 1989).

A number of studies have found strong relationships between the communication of STI and technical performance at both the individual (Allen, 1970b; Hall and Ritchie, 1975;Rothwell and Robertson, 1973) and group levels (Carter and Williams, 1957; Rubenstein, et al., 1971;Smith, 1970). As Fischer (1980) concludes, "The role of scientific and technical communication is thus central to the success of the innovation process, in general, and the management of R&D activities, in particular." But as Solomon and Tornatzky (1986) point out, "While STI, its transfer and utilization, is crucial to technological innovation [and competitiveness], linkages between [the] various sectors of the technology infrastructure are weak and/or poorly defined."

The importance of the U.S. aerospace industry to the American economy is illustrated in the following commentary offered by the Aerospace Industries Association (1990).

> Last year U.S. aerospace exports totaled nearly $32 billion. Imports of similar goods were approximately $10 billion for a positive sectoral trade balance of $22 billion. This was a net improvement of $4 billion over 1988. In fact, the U.S. sectoral trade balance in aerospace products has improved every year since 1984. The contrast to other U.S. manufacturing industries is striking. The trade trend for high-tech U.S. industries, such as computers and automobiles, has been steadily negative. For such industries the goal is reversing these persistent negative trends; for U.S. aerospace, the goal is to maintain its positive trade balance.

In spite of its importance to the U.S. economy and the balance of trade, very little is known about technological innovation and the diffusion of knowledge and the aerospace industry, both in terms of the channels used to communicate the ideas and the information-gathering habits and practices of the members of the aerospace social

system. Most of the channel studies, such as the work by Gilmore, et al., (1967) and Archer (1964), have been concerned with the transfer of aerospace technology to non-aerospace industries. Most of the studies involving aerospace engineers and scientists, such as the work by McCullough, et al., (1982) and Monge, et al., (1979), have been limited to the use of NASA STI products and services and have not been concerned with information-gathering habits and practices. Although researchers such as Davis (1977) and Spretnak (1982) have investigated the importance of technical communications to engineers, it is not possible to determine from the published results if the study participants included aerospace engineers and scientists.

Therefore, it is likely that an understanding of the process by which aerospace STI is communicated through certain channels over time among the members of the aerospace social system would contribute to stimulating technological innovation, maximizing the R&D process, increasing R&D productivity, and improving and maintaining the professional competence of U.S. aerospace engineers and scientists.

Despite the vast amount of STI available to potential users, several major barriers to effective knowledge diffusion exist (Bikson, et al., 1984). **First**, the very low level of support for knowledge transfer in comparison to knowledge production suggests that dissemination efforts are not viewed as an important component of the R&D process. **Second**, there are mounting reports from users about difficulties in getting appropriate information in forms useful for problem solving and decision making. **Third**, rapid advances in many areas of S&T knowledge can be fully exploited only if they are quickly translated into further research and application. Although the United States dominates basic R&D, foreign competitors may be better

able to apply the results. **Fourth,** current mechanisms are often inadequate to help the user assess the quality of available information. **Fifth,** the characteristics of actual usage behavior are not sufficiently taken into account in making available useful and easily retrieved information. These deficiencies must be remedied if the results of federally funded R&D are to be successfully applied to innovation, problem solving, and productivity. Only by maximizing the R&D process can the United States maintain its international competitive edge in aerospace.

Finally, while the literature review does contribute to the broader purpose of the study, it falls short of answering the fundamental research question posed by this study. Historical and empirically derived evidence exists to support the claim that technical reports are used by and are important information products to engineers. The results of the exploratory study (Pinelli, et al., 1989) indicate that U.S. government technical reports are used by U.S. aerospace engineers and scientists. The role played by the U.S. government technical report in the diffusion of federally funded aerospace R&D is unknown. The relationship between the information-seeking habits and practices of U.S. aerospace engineers and scientists and the U.S. government technical report is also unknown. The extent to which the six institutional or structural variables influence the use of U.S. government technical reports by U.S. aerospace engineers and scientists is not known. The extent to which the seven sociometric or source selection variables influence the use of U.S. government technical reports cannot be determined from the available literature.

Table 16. Knowledge Diffusion and Technological Innovation

Year	Author	Findings and recommendations
1989	Curlee and Goel	Presented a general overview (survey) of the economics literature on transfer and diffusion of new technologies. Presented the arguments, both pro and con, for government involvement in technological innovation.
1983	Glaser, Abelson, and Garrison	Reported on an early attempt to collect and distill the relevant literature from the social sciences associated with the diffusion of knowledge and knowledge utilization. Looked at the barrier and gateways related to dissemination, transfer, and utilization of knowledge and concentrated on the development of strategies to facilitate knowledge diffusion in organization and institutionalized settings.
1975	Kelly and Kranzberg	Reported the results of an investigation concerned with determining what is known about technological innovation. This ambiguous investigation collected, revised, and critiqued the literature from a variety of disciplines; identified the "gaps" and "weaknesses" regarding what is known about technological innovation; determined the various methodologies and approaches that were used; looked at technological innovation within an individual and organizational content; and looked at technological innovation within a larger "system" context.

Table 16. Concluded

Year	Author	Findings and recommendations
1986	Landau and Rosenberg	Recognized as a significant contribution to the understanding of knowledge diffusion and technological innovation. Established a clear link between technological innovation and economic theory. Stressed that while technological innovation is different in each industry, knowledge diffusion is common to technological innovation and, thus, all industries.
1985	Mahajan and Peterson	Reviewed the "several most widely cited mathematical diffusion models" found in the literature. Explained the development of these models and presented a "generality" of these models across disciplines and innovations.
1983	Rogers	This work is recognized as a "landmark" effort in the field of knowledge diffusion. Represented an empirical investigation of knowledge diffusion from a communications standpoint. Indicated there are four key elements in the diffusion process—the innovation, channels of communication time, and the social system.

Table 17. Knowledge Diffusion, Technological Innovation, and Government Policy

Year	Author	Findings and recommendations
1989	Ballard, et al.	Investigated the transfer and use of federally funded STI to improve technological innovation and the international competitiveness of American industries. Concluded that major changes must occur at the federal level and within industry before the results of Federally funded R&D can make a difference in U.S. competitiveness.
1984	Chakrabarti and Souder	Reported on the critical factors that affect the innovation process and some ways in which government can influence technological innovation. Concluded that the transfer of government-funded knowledge to industry is a vital part of any government policy directed toward technological innovation.
1986	David	Reported that it is hard to exaggerate the economic significance of technology or knowledge diffusion. Stated that more knowledge "production," not better knowledge "transfer," is considered by government policymakers to be crucial to successful technological innovation. Described the absence of technology and knowledge diffusion from the report, *Global Competition,* as "the dog which did not bark in the night."
1974	Eads	Examined the economic concept of "externalities" (i.e., the underinvestment of knowledge production) as a justification for U.S. government intervention in the process of developing commercial technology. Stated that this concept is not well understood by policymakers and illustrated the point with a list of U.S. government policies that have had a significant impact on the rate or direction of technological change in the U.S. commercial aircraft industry.

Table 17. Continued

Year	Author	Findings and recommendations
1968; 1982; 1975; 1977	Mansfield; Mansfield, et al.; Romeo; Romeo	Mansfield and his research team created the "new microeconomics of innovation diffusion," which is concerned with the adoption of new technologies by industries. This work was directed toward identifying common features and determinants of technology and the knowledge diffusion process. This work stressed the importance, from a government policy perspective, of investing in technology and knowledge diffusion.
1983	Mowery	Reported that Federal proposals and program experiments aimed at improving the innovative performance of American industry are based on an economic model that emphasizes the undersupply of knowledge production which leads to Federal support for knowledge production. Stressed that this model is based on an inappropriate analytic framework. A more appropriate analytic approach is the "information processing" framework, which places greater emphasis on the transfer and utilization of knowledge.
1979	Mowery and Rosenberg	Reported on an analysis of empirical studies concerned with the influence of market demand on the process of technological innovation. Concluded that while these studies support the proposition that market demand governs the process of technological innovation, the proposition is by no means conclusively demonstrated by these studies. Further, they concluded that both demand (market) and supply side influences are crucial to technological innovation and that government policies should pay greater attention to supply. (i.e., knowledge transfer and utilization).

Table 17. Continued

Year	Author	Findings and recommendations
1982	Nelson	Reported on the nature of public policies that have influenced the pace and pattern of technical progress in seven key American industries. These policies include, among others, knowledge transfer and utilization and the industries, including commercial aviation. Concluded that each of these policies (i.e., knowledge transfer and utilization) must be applied differently in each industry.
1976	Pavitt and Walker	Conducted a review of what is known about government policies towards technological innovation. The purpose was to formulate a list of ways in which government can influence technological innovation. Concluded that the transfer of government-funded knowledge to industry is a vital part of government policy regarding civilian R&D.
1978	Roberts and Frohman	Reported on how Federal agencies approach research (knowledge) utilization and transfer. Stated that most of the approaches used by Federal agencies have been ineffective in stimulating the diffusion of technological innovation.
1986	Solomon and Tornatzky	Reported that past Federal efforts to stimulate technological innovation have been largely ineffective because they either tinkered unsuccessfully with macroeconomic policy or merely threw money at the problem under the mistaken belief that the government could "buy" technological innovation. Concluded that America has no integrated, coherent innovation policy. Such policy, to be successful, would have to make provision for knowledge diffusion and transfer.

Table 17. Concluded

Year	Author	Findings and recommendations
1986	Stoneman and David	Focused on government policies that aim to influence the diffusion of technological innovation into actual use. Noted that government largely attempts to speed up the diffusion of new knowledge two ways—by information provision (e.g., Federal information programs and systems) and by the use of subsidies (e.g., favorable leasing terms and tax credits).
1990	Tornatzky	Examined the issues of science and technology policy as they relate to technological innovation. Stated that "diffusion of knowledge" is one of several policy tools available to government policymakers concerned with technological innovation.

Table 18. Knowledge Diffusion, Technological Innovation, and STI

Year	Author	Findings and recommendations
1966; 1966; 1968; 1969; 1970; 1982	Allen; Marquis and Allen; Allen; Allen and Cohen; Allen; Katz and Allen	Discussed a series of investigations into the STI needs of engineers; the relationship between STI and project task or function; the flow of STI in R&D laboratories; and the relationship between STI, technical performance, and the productivity of R&D projects.
1967; 1972	Baker, Siegman, and Rubenstein; Baker and Freeland	Discussed the relationship and role of STI to the generation of ideas for R&D projects and solutions to technical problems including the organizational factors affecting the flow of STI and the sources and channels used to obtain STI. The critical problems of STI search and dissemination were also examined.
1987	Batson	Reported that the characteristics of R&D and R&D management influence the STI needs of managers and researchers. Since R&D is largely an information processing activity, the availability and flow of STI is critical to successful R&D. How R&D managers and researchers gather, process, and communicate STI is directly related to successful R&D.
1982	Bozeman and Cole	Reported on the role of channel preference and gatekeepers in the acquisition of STI in public R&D organizations.
1983	Chakrabarti, Feineman, and Fuentevilla	Reported on the use of STI by researchers and the various dimensions or characteristics of the sources, channels, and contents associated with STI and their relationship to frequency of use.
1977	Chakrabarti and O'Keefe	Reported on the role played by "key" communicators in 3 U.S. government laboratories engaged in R&D in linking researchers within the labs with STI from the external information environment.

Table 18. Continued

Year	Author	Findings and recommendations
1988	Davis and Wilkof	Reported that firms engaged in R&D have a choice of how to effectively organize. The organizational structure and processes they implement have major effects on how STI is transferred as well as the quality of the STI that is disseminated and used.
1971; 1978	Dewhirst; Dewhirst, Arvey, and Brown	Reported on the relationship between the perceived information sharing norms and the use of information channels both inside and outside a U.S. government aeronautical research laboratory. Reported on the relationship between information accessibility and (1) STI generated inside the organization, (2) STI generated outside the organization, and (3) goal-related STI.
1984	Ebadi and Utterback	Reported that access to STI and frequency of use affect R&D project success. Hence, R&D projects should be organized and managed to formulate the flow of STI.
1979; 1980	Fischer; Fischer	Reported on the process of STI acquisition by R&D managers for problem solving. Reported on a survey of the literature on STI as it relates to innovation and discussed how STI can improve the efficacy of technological innovation and the R&D process.
1971; 1973	Frost and Whitley; Whitley and Frost	Reported on a study that duplicated, in a British R&D facility, some of Allen's work on the flow of STI in R&D organizations. Reported on the acquisition of STI through informal and formal sources and channels into a British R&D facility and the formation of internal information barriers.

Table 18. Continued

Year	Author	Findings and recommendations
1980	Gerstenfeld and Berger	Reported on the process of STI transfer in 5 major U.S. corporations; the use of STI was analyzed in terms of the task to be performed and the characteristics of the information used.
1974	Gibbons and Johnson	Reported on an analysis of 30 innovations, focusing upon the origins and character of informational inputs used to solve technical problems in the innovation process. Information inputs were analyzed in terms of internal and external and scientific and technical.
1976	Goldhar, Bragaw, and Schwartz	Reported on the use and flow of information and management styles in several recently completed empirical studies of successful technological innovations.
1984	Heaton and Holloman	Reported that the diffusion of technological innovation is a strategy that the United States has undervalued too long. The same is true for Federal technology programs, which are characterized by massive R&D expenditures. STI is critical to technological innovation. Simply put, the United States must make a major effort to ensure that the results of federally funded R&D are utilized.
1976	Holland, Stead, and Leibrock	Reported on an investigation into the relationship between technical uncertainty and the selection of STI channels and sources by engineers and scientists in a large U.S. government R&D organization.
1988	Lee and Treacy	Reported that STI is critical to innovation. Information technology will enhance innovation by providing access to STI.

Table 18. Concluded

Year	Author	Findings and recommendations
1975	Johnson and Gibbons	Reported on the characteristics of STI used to resolve technical problems in British industry technological innovations and R&D projects.
1985	Opren	Reported on the influence of R&D managers on R&D workers and their use of STI originating outside the organization.
1975	Rothwell	Reported on an analysis of the available empirical data that relate to the information-seeking habits of innovators in their search for STI.
1973	Rothwell and Robertson	Reviewed the more significant empirical research in the field of technological innovation, emphasizing the patterns of STI flow and STI use by research personnel.
1975	Taylor and Utterback	Reported on STI patterns in a large R&D laboratory and how technical and managerial influences affect R&D communications.
1980	Tushman and Katz	Reported on an investigation of the role of gatekeepers and the transfer of STI in a single R&D organization.
1990	U.S. Congress, Office of Technology Assessment (OTA)	Reported that the United States must make better use of its STI resources if it wishes to be competitive in world markets and maintain its leadership. STI is an essential ingredient of the innovation process.
1971	Utterback	Reported on the channels and sources of STI used in technological innovation and the production of new scientific instruments.

Table 19. Knowledge Diffusion, Technological Innovation, and Federally Funded Aerospace R&D

Year	Author	Findings and recommendations
1987	Aerospace Industries Association (AIA)	Reported that the competitive position of the U.S. commercial aviation industry is eroding. Proposed a national strategy to improve the position of the U.S. aviation industry in the competitive global arena by focusing on the development of key technologies. Emphasized the need for cooperative ways to share in the development and utilization of these key technologies.
1988	AIA	Reported on "technological readiness" as the long-term market strength of U.S. civil aircraft manufacturers. Emphasized the importance in "technology readiness" for application and the need to "transfer" new technology promptly to U.S. industry.
1971	Booz-Allen	Reported on an analysis of federally funded aeronautical R&D since 1945 and the benefits that accrued from the transfer of this technology to U.S. commercial aviation.
1982	Fraser and Maggin	Investigated the role and need for continued U.S. government support of aeronautical R&D. Concluded that U.S. commercial aviation will not and cannot invest in the R&D necessary to ensure long term industry leadership.
1978	Gellman and Price	Examined the question of technology transfer vis-à-vis U.S. commercial aviation through international arrangements for the production of commercial transport aircraft.

Table 19. Continued

Year	Author	Findings and recommendations
1972; 1972	Hudson; Paulisick	Reported on the advances made in U.S. commercial aviation since 1925, the significant technological advances that have taken place in U.S. commercial aviation, and the relationship between these advances and federally funded aeronautical R&D.
1989	March	Reported on the U.S. commercial aircraft industry and its foreign competitors. Provided an historical overview of aviation since 1945, the development of foreign competition, the changing competitive environment, and what the U.S. commercial aircraft industry will have to do to compete in this environment.
1985	Mowery	Discussed the importance of federally funded research investment on the technological and economic performance of the U.S. commercial aircraft industry. Focused on the role of such investment within a policy structure that has affected both the supply of innovation and the demand for the embodiment of those innovations in new commercial aircraft design and production.
1982	Mowery and Rosenberg	Examined the innovation process within the U.S. commercial aircraft industry, focusing particularly upon the role of U.S. S&T policy in affecting the pace and structural context within which technological innovation has occurred. Concluded that U.S. government policy has influenced the adoption of innovation in the U.S. commercial aircraft industry through "supply-push/demand pull" activities.

Table 19. Continued

Year	Author	Findings and recommendations
1985	Mowery and Rosenberg	Reported on the potential viability of the Japanese in becoming an independent force in commercial aviation. Concluded that the Japanese commercial aviation industry, in its present state, is far from having the capability to operate independently in the large commercial transport market.
1985	National Academy of Engineering	Reported on the influence of technology and technological innovation in determining the international competitiveness of the U.S. commercial aviation industry. Examined U.S. government policies and practices that may bear on technological innovation and adoption in the U.S. commercial aviation industry.
1982	Office of Science and Technology Policy (OSTP)	Reviewed the appropriateness and effectiveness of U.S. aeronautical R&D policies and the role of the Federal government in supporting aeronautical R&D. Considered the role of the Federal government as a transfer agent for knowledge diffusion. Concluded that Federal involvement in funded aeronautical R&D is necessary if the U.S. is to remain internationally competitive.
1985	OSTP	Proposed 3 national R&D goals to clarify and focus the direction of U.S. aeronautical R&D. These goals clearly emphasize knowledge production at the expense of knowledge transfer and do not mention the role of the Federal government in transferring the results of U.S. government-funded R&D to the U.S. aeronautical community.

Table 19. Concluded

Year	Author	Findings and recommendations
1987	OSTP	Presented a refinement of the national R&D goals published in 1985. As in 1985, the focus was on knowledge production with no mention of knowledge transfer.
1978	Rosenberg, Thompson, and Belsley	Examined the progress of U.S. commercial aviation in terms of invention, development, production, and improvement phases. Stated that technological advances resulting from aeronautical R&D have resulted in dramatic productivity increases for the U.S. commercial aviation industry.
1983	Trilling	Traced the history of the development of large body commercial jet aircraft in the U.S. Discussed the transfer of technology, first developed to meet military needs, to the U.S. commercial aviation industry.
1988	U.S. Department of Commerce	Reported on the competitive portion of the U.S. civil helicopter industry. Looked at the structure of the industry, the economic characteristics of the industry, factors affecting growth, foreign competition, and the implications of U.S. government policies on technological innovation.

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CHAPTER 4

RESEARCH METHODOLOGY AND DESIGN

INTRODUCTION

This chapter contributes to the immediate and broader purposes of the study by establishing an understanding of the research design and methodology used to collect and analyze the data. To establish this understanding, the background, theoretical development, conceptual framework, and hypotheses that underlie the study are presented. Furthermore, the study's research design and methodology are explained at a level of detail sufficient to provide ample and adequate detail to duplicate the study.

BACKGROUND

This study was conducted as a Phase 1 activity of the NASA/DOD Aerospace Knowledge Diffusion Research Project. Phase 1 of the project is concerned with the information-seeking habits and practices of U.S. aerospace engineers and scientists, with particular emphasis placed on their use of government-funded aerospace STI products and services. *This* study, which spanned the period from May 1989 through February 1990, was conducted in conjunction with the Indiana University Center for Survey Research. Professional research assistance was utilized to help ensure confidentiality, to maintain the integrity of the study and the research process, and to obtain the skills needed to design and conduct a study of this complexity and magnitude.

THEORETICAL DEVELOPMENT

Theory and research are inseparable in the traditional model of science (Wallace, 1971). According to this model, theory generates hypotheses, hypotheses suggest observations and/or experimentation, observations and/or experimentation produce generalizations, and generalizations result in modifications of theory. Modifications in theory lead to modified hypotheses and a new set of observations and/or experimentation, which produce somewhat revised generalizations, further modifying the theory.

The theoretical basis for *this* study is derived in large part from work by Orr (1970) and Mick (1979). Their work is grounded in the following three assumptions: (1) that a holistic or global view is necessary to understand and predict the communication behavior of engineers and scientists; (2) that the communication behavior of engineers or scientists can be viewed as a system of information input and output activities, can be characterized as a series of complex interactions, and is influenced by a variety of factors or variables; and (3) that these factors or variables, either individually or collectively, influence information processing and, therefore, can be used to understand and predict the use and production of an information product and the engineers' or scientists' communication behavior. These factors or variables may be variously grouped as personal, situational, organizational, and environmental.

Orr (1970) theorizes that these variables combine to influence information use and production. According to Orr, the impact or influence of these variables is estimated subjectively by the engineer or scientist who, in turn, makes a decision based on their time; the physical-psychological effort required, and the perceived likelihood of success, as opposed to perceived benefit, in acquiring the desired information.

CONCEPTUAL FRAMEWORK

To describe, understand, and eventually predict the information-seeking habits and practices of U.S. aerospace engineers and scientists, it is useful and perhaps necessary to plan and conduct "user" studies within a conceptual framework. According to Mick (1979), a conceptual framework is needed to "develop theories that explain and predict information-seeking behavior and that can be applied to problems involving either the management of information work or the design of information products, services, and systems."

Several schemas specifically concerned with information-seeking behavior have been advanced through the years. Notable examples include the work by Paisley (1968), Orr (1970), Allen (1977), and Mick (1979). Paisley, who focuses on information-seeking behavior at the individual level, defines a number of systems within which the engineer or scientist operates. Allen focuses on the information-seeking behavior of engineers in work groups conducting mission-oriented research. Orr concentrates on the engineer-scientist as an information processor. Mick's work centers on information behavior within a corporate-work structure and emphasizes a more policy-oriented approach to user behavior.

The conceptual framework for *this* study, shown in figure 10, is based on the work of Paisley, Allen, and Mick and represents an extension of Orr's scheme of the engineer-scientist as an information processor. The framework for *this* study focuses on information seeking and assumes that, notwithstanding individual differences, there is an internal, consistent logic that governs the information-seeking behavior of U.S. aerospace engineers and scientists.

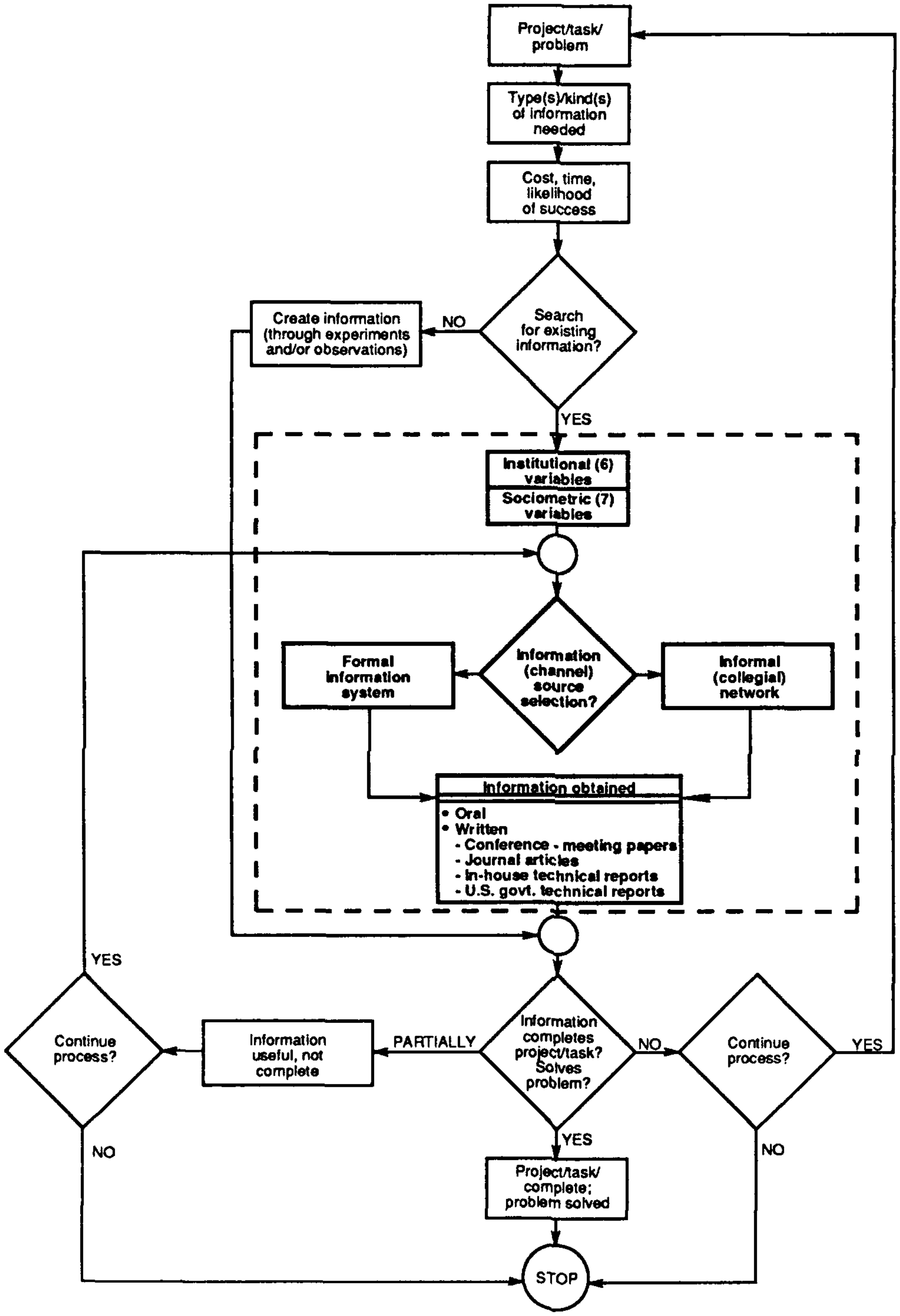

Figure 10. The U.S. Aerospace Engineer and Scientist as an Information Processor: A Structured Analysis With Data on Variables Related to Information-Seeking Habits and Practices.

The Engineer As An Information Processor

As Paisley (1968) points out, the engineer-scientist can be viewed as the center of many systems. The selection of a particular system or systems depends on a number of considerations. For purposes of *this* study, U.S. aerospace engineers and scientists are placed within the following four systems: **the political system**, because the study is concerned with the diffusion of federally funded aerospace knowledge; **the formal organization**, because the information-seeking habits and practices of U.S. aerospace engineers and scientists are viewed in terms of academic, government, and industry affiliation; **the reference group**, because the study focuses on those U.S. aerospace engineers and scientists whose duties are primarily or exclusively research; and **the formal information system**, because the study is concerned with the role occupied by formal information systems in the diffusion of federally funded R&D. However, because the study also attempts to explore, describe, and explain the use of U.S. government technical reports, U.S. aerospace engineers and scientists are viewed as information processors within a conceptual framework of information seeking.

A project, task, or problem that precipitates a need for information is central to the conceptual framework for *this* study. This need for information may, in turn, be **internally** or **externally** induced and is referred to by Orr (1970) as **inputs** or **outputs,** respectively. Inputs originate within the mind of the individual engineer-scientist and include information needed to keep up with advances in one's profession and to perform one's professional duties (Voight, 1961; Menzel, 1964) and to obtain stimulation and feedback from and to interact with peers, colleagues, and coworkers (Storer, 1966; Hagstrom, 1965).

Outputs frequently, but not exclusively, result from an external stimulus or impetus. Outputs serve a variety of functions, including responding to a request for information from a supervisor, a coworker, peer, or colleague; reporting progress; providing advice; reacting to inquiries; defending; advocating; and proposing. Inputs and outputs require the use of specific kinds and types of information.

The conceptual framework for *this* study assumes that, in response to a project, task, or problem, a specific kind(s) or type(s) of information is needed. In response to this scenario, U.S. aerospace engineers and scientists are confronted with two basic alternatives: they can create the information through experimentation or observation or they can search the existing information (Orr, 1970). Orr postulates that if they act rationally, the decision to "make or buy" the information will depend upon their "subjective estimate or perception of the relative likelihood of success in acquiring the desired information by these two alternatives within an acceptable time, and on their perception of the relative cost [money and/or effort] of these alternatives."

If a decision is made to search the existing information, U.S. aerospace engineers and scientists effectively are faced with a decision or a choice of two information channels. One is the **informal or collegial network**, which is characterized by interpersonal (oral) communications with peers, coworkers, colleagues, gatekeepers, vendors, consultants, "key" personnel, and supervisors and by personal collections of information. The other is the **formal information system**, which includes libraries, technical information centers, librarians and technical information specialists, information products and services, and information storage and retrieval systems.

It is assumed that the decision to choose a particular information channel is influenced

by several institutional factors or variables operating within the previously identified systems. It is proposed that certain sociometric variables influence information source and product selection. Gerstberger and Allen (1968), Rosenberg (1967), and Orr (1970) theorize that information source and product selection are influenced by these variables.

The resulting information is subjectively evaluated. The information processor is faced with three possible courses of action. **First**, if the acquired-obtained information completes the project or task or solves the problem, the process is successfully terminated. **Second**, if the acquired-obtained information is useful but only partially completes the project or task or partially solves the problem, a decision is made to either continue the process by reevaluating the information source selection or terminate the process. **Third**, if the acquired-obtained information is not applicable to or does not complete the project or task or solve the problem, a decision is made to either continue the process by redefining the project, task, or problem or to terminate the process.

Because the broader purpose of the study is to provide insight regarding the information-seeking habits and practices of U.S. aerospace engineers and scientists, the study is cast within a conceptual framework that focuses on information seeking. However, since the immediate purpose of the study is to provide an empirical basis for understanding the role of the U.S. government technical report in the diffusion of knowledge resulting from federally funded aerospace R&D, the conceptual framework is investigated but not validated. Instead, the study focuses on the information acquired or obtained through the source selection process and the institutional and sociometric variables associated with that portion of the conceptual framework.

Dependent and Independent Variables

Potentially, there are four dependent variables: conference-meeting papers, journal articles, in-house technical reports, and U.S. government technical reports. The **dependent** variable selected for the study is the number of U.S. government technical reports used in a 6-month period. There are six institutional and seven sociometric variables that serve as the **independent** variables for the study. The six institutional variables include level of education, operationally defined as the presence or absence of a graduate degree; educational preparation, operationally defined as either engineer or scientist; years of professional work experience, operationally defined as 0 to 15 years and 16 years and over, organizational affiliation, operationally defined as academic, government, and industry; primary professional duties, operationally defined as management and nonmanagement; and technical discipline, operationally defined as engineering and nonengineering.

The seven sociometric variables include accessibility, operationally defined as the ease of getting to an information source; ease of use, operationally defined as the ease of understanding, comprehending, or utilizing the information source; expense, operationally defined as the expense in either time, effort, or money in comparison to another information source; familiarity or experience, operationally defined as prior knowledge or previous use of an information source; technical quality or reliability, operationally defined as the expectation that the information source would be the best in terms of quality; comprehensiveness, operationally defined as the expectation that the information source would provide broad coverage of the available knowledge; and

relevance, the expectation that a high percentage of the information acquired or obtained from the source would be useful.

Other variables central to the study include the project, task, or problem and the types and kinds of information respondents use in performing their present professional duties. Project, task, or problem is operationally defined two ways: educational, research, and management, following the work by King, et al., (1982), and research, design, development, manufacturing, production, computer applications, and management, following Kaufman's work (1983). The types and kinds of information are operationally defined as basic scientific and technological information, in-house technical data, computer programs, technical specifications, and product and performance characteristics, following the work of Shuchman (1981) and Pinelli, et al., (1989).

Hypotheses

The goal of *this* study is to provide an empirical basis for understanding the role of the U.S. government technical report in the diffusion of knowledge resulting from federally funded aerospace R&D. Assuming that the U.S. government technical report plays an important, but as yet undefined, role in the aerospace knowledge diffusion process, it follows that three research questions are generated. First, do the six institutional or structural variables explain the use of U.S. government technical reports by U.S. aerospace engineers and scientists? Second, do the seven sociometric or source selection variables explain the use of U.S. government technical reports by U.S. aerospace engineers and scientists? Third, if both the institutional and sociometric variables are considered, does one set of variables predominate in terms of use?

The following hypotheses were formulated based on the three research questions. The hypotheses were formulated on "an assumption of difference" and, therefore, are stated as **alternative** hypotheses. Each hypothesis was tested with a statistical significance of $p \leq 0.05$. Use of U.S. government technical reports was measured in a 6-month period. Finally, 95 percent of the respondents were educated as either aerospace engineers or scientists. Only respondents who use the U.S. government technical reports (96.6 percent) were used to test the hypothesis.

H_1: Presence or absence of a graduate degree significantly influences the use of U.S. government technical reports by U.S. aerospace engineers and scientists.

H_2: Academic preparation as an engineer or scientist significantly influences the use of U.S. government technical reports by U.S. aerospace engineers and scientists.

H_3: Years of professional work experience (15 or less and 16 or more) significantly influences the use of U.S. government technical reports by U.S. aerospace engineers and scientists.

H_4 Academic, government, and industry organizational affiliation significantly influences the use of U.S. government technical reports by U.S. aerospace engineers and scientists.

H_5: Management and nonmanagement professional duties significantly influence the use of U.S. government technical reports by U.S. aerospace engineers and scientists.

H_6: Engineering and nonengineering disciplines or duties significantly influence the use of U.S. government technical reports by U.S. aerospace engineers and scientists.

H_7: Accessibility, as opposed to the other sociometric variables, significantly influences the use of U.S. government technical reports by U.S. aerospace engineers and scientists.

H_8: The institutional or structural variables, as opposed to the sociometric or source selection variables, significantly influence the use of U.S. government technical reports by U.S. aerospace engineers and scientists.

RESEARCH METHODOLOGY

Social science research, the umbrella under which user studies and *this* study fit, serves many purposes. According to Babbie (1986), three of the most common and useful purposes include **exploration, description**, and **explanation**. *This* study attempts to **explore** the amount of use of U.S. government technical reports by U.S. aerospace engineers and scientists, to **describe** the information-seeking habits and practices of U.S. aerospace engineers and scientists, and to **explain** the influence of selected institutional and sociometric variables on the use of U.S. government technical reports by U.S. aerospace engineers and scientists.

Saracevic and Wood (1981) state that surveys, observations, record analysis, and experimentation are the research methods most often used with user studies. Of these possibilities, survey research in the form of a self-administered mail questionnaire was the research methodology used with this study. The survey design was based primarily on Dillman's (1978) total design method (TDM) for mail surveys. There are three reasons for choosing survey research over the other possible methodologies.

First, there are specific limitations associated with each research method not selected. Observation was discounted because of the time and expense required and because access to a sufficient number of aerospace organizations and installations could not be obtained. Record analysis could not be used because no suitable primary or secondary sources or records were found that could be analyzed. Experimentation was considered to be inappropriate because of the purpose and nature of the study. **Second**, survey research was selected because of the ability of this methodology to gather data on a population that is too large and geographically dispersed to observe

directly. By distributing a self-administered questionnaire to a randomly chosen sample, the relative incidence, distribution, and interrelationship between variables could be observed. **Third,** the use of a questionnaire permits large amounts of data to be collected and manipulated in a uniform manner (Babbie, 1986).

Survey Research

Survey research studies large and small populations (or universes) by "selecting and studying samples chosen from the populations to discover the relative incidence, distribution, and interrelations of sociological and psychological variables. Although used by many disciplines, survey research is considered to be a branch of social scientific research. Its procedures and methods have been developed mostly by psychologists, sociologists, economists, political scientists, and statisticians. Surveys can be conveniently classified by the following methods of obtaining information: personal interview, mail questionnaire, panel, and telephone" (Kerlinger, 1986).

Survey research has contributed much to the methodology of the social sciences. "Its most important contributions, perhaps, have been to rigorous sampling procedures, the overall design and the implementation of the design of studies, the unambiguous definition and specification of the research problem, and the analysis and interpretation of data" (Kerlinger, 1986). In the limited space of a section of one chapter, however, it is impossible to discuss adequately the methodology of survey research. Interested readers are referred to the following sources for additional detail regarding survey research methodology: Alreck and Settle (1985), Babbie (1973), and Fowler (1984).

A basic assumption in social research is that all research methods have limitations and special strengths and weaknesses and that all measurement involves

error. The researcher's task is one of selecting the appropriate research method, maximizing its strengths, compensating for its weaknesses, and reducing measurement error as much as possible.

Nachmias and Nachmias (1987) view the mail questionnaire as an impersonal survey method. The advantages and disadvantages of mail questionnaires are as follows:

Advantages

- Mail surveys are particularly useful in describing the characteristics of large populations; they are flexible in that many questions can be asked on a given topic (Babbie, 1986).

- Mail surveys are the least expensive means of gathering large amounts of data about a large population (Kidder and Judd, 1986).

- Mail questionnaires can be sent to all respondents simultaneously. Although the final returns may take several weeks, interviews are generally performed sequentially and may take months to complete. Once questionnaires are mailed, the researcher is free to work on other aspects of the project (Bailey, 1978).

- Mail questionnaires reduce interviewer bias that might result from the personal characteristics of interviewers and from the variabilities in their skills. There are many possibilities for bias that may arise in a personal interview situation because of the nature of the personal interaction between the interviewer and the respondent. This can be completely avoided with a mail questionnaire (Nachmias and Nachmias, 1987; Kidder and Judd, 1986).

- Mail questionnaires are credited with giving respondents a greater feeling of anonymity, which is especially helpful with surveys that deal with sensitive issues. Given the absence of an interviewer, respondents are more likely to respond openly to sensitive questions (Bailey, 1978; Kidder and Judd, 1986; Nachmias and Nachmias, 1987).

- Mail questionnaires permit wider geographic contact with minimal cost. Interviewing a population that is widely dispersed geographically would involve considerable travel cost and time (Nachmias and Nachmias, 1987).

- Mail questionnaires are preferable when questions demand a considered (rather than an immediate) answer or if the answer requires consultation of personal documents or of other people (Kidder and Judd, 1986; Nachmias and Nachmias, 1987).

- Mail questionnaires permit the use of standardized questions. Comparison of respondents' answers is facilitated by the fact that each respondent is exposed to exactly the same wording. Likewise, by asking each respondent exactly the same question, the researcher is bound to assign the same intent to all respondents giving a particular response (Babbie, 1986; Bailey, 1978).

Disadvantages

- It is often difficult to obtain an adequate response rate with mail questionnaires. Assuming that nonrespondents are different from respondents, researchers who use mail questionnaires are faced with the problem of how to estimate the effect the nonrespondents may have on their findings (Kerlinger, 1986; Nachmias and Nachmias, 1987).

- Mail questionnaires do not allow an interviewer to correct misunderstandings or answer questions that the respondents have (Bailey, 1978). Questions must be straightforward so that they can be comprehended solely with the help of printed instructions and definitions. The answers have to be accepted as final. There is no opportunity to probe beyond the given answer (Nachmias and Nachmias, 1987).

- With a mail questionnaire, researchers have no control over the respondent's actions. They cannot be sure that the right person completes the questionnaire. An individual other than the intended respondent may complete it (Nachmias and Nachmias, 1987). Additionally, researchers cannot control the date of response. They can only ask for the questionnaire to be returned by a specific date (Bailey, 1978).

- Certain environmental concerns are associated with mail questionnaires. First, it is often important that the respondent answer one question before seeing or answering another. With a mail questionnaire, there is no way to control question order (Kidder and Judd, 1986). Second, with personal interviews, great care is usually taken to ensure that a standardized environment exists for every interviewee. No such assurance can be made for mail surveys (Bailey, 1978). Third, respondents are likely not to answer all questions. While the overall response rate may be fixed, the response rate for each question may vary (Bailey, 1978).

Validity and Reliability

According to Babbie (1986), survey research is generally weak on validity and strong on reliability. The validity of mail questionnaires can be assessed by comparing the findings from a mail questionnaire with previously known facts (Bailey, 1978). Validity for *this* study was established in the following three ways: (1) the questions used in *this* study were compared with those used in studies by Allen (1977), Shuchman (1981), and Kaufman (1983), which were concerned with the information-seeking habits and practices of engineers and scientists; (2) the questions were further developed through the administration of a pilot study (Pinelli, et al., 1989) that was administered to a randomly drawn sample of U.S. aerospace engineers and scientists belonging to the American Institute of Aeronautics and Astronautics (AIAA); and (3) the questionnaire was pretested with 3 groups of 25 aerospace engineers and scientists at the NASA Langley Research Center.

According to Babbie (1986), reliability in survey research is easier to ascertain than validity. Presenting all respondents with a standardized stimulus, according to Bailey (1978), goes a long way toward eliminating unreliability. Conversely, survey research deals almost exclusively with reports of behavior rather than with observations of behavior, a factor that tends to weaken reliability (Singleton, et al., 1988).

Two methods were available to help ensure reliability. **First**, particular demographic information regarding the population was contained in the AIAA National Membership Profile. Certain of the demographic information collected in *this* study could be compared to "known" data to determine the accuracy of "reported" data. **Second**, a variation of Flanagan's critical incident technique was used to help ensure

reporting accuracy.[5] According to Lancaster (1978), the theory behind the critical incident technique is that it is much easier for people to recall accurately what they did on a specific occurrence or occasion than it is for them to remember what they do in general. In *this* study, questions specifically concerned with information use were framed in terms of "a specific time period"; "their present professional duties"; and "the most important project, task, or technical problem" within the past 6 months.

Response Rate

According to Bailey (1978), a large number of factors can affect response rates and also account for the tremendous variation in response rates in mail questionnaires. Given this extreme variation, what constitutes an adequate response rate? Babbie (1973) offers the following comment:

> I feel that a response rate of at least 50 percent is **adequate** for analysis and reporting. A response rate of at least 60 percent is **good**. And a response rate of 70 percent or more is **very good**. The reader should bear in mind, however, that these are only rough guides; they have no statistical basis, and a demonstrated lack of response bias is far more important than a high response rate.

Drew and Hardman (1985) state that there is no wide consensus among researchers regarding these figures. Bailey (1978), on the other hand, states that researchers should not be satisfied with such low response rates and that "serious researchers should undertake several steps to substantially increase the return."

[5]The critical incident technique was formulated by John C. Flanagan and is discussed in an article for which the citation appears in the references.

According to Bailey, a properly constructed mail questionnaire and appropriate follow-up should result in a 75-percent response rate. According to Singleton, et al., (1988), however, nonrespondents or "nonobservations tend to differ in systematic ways from observations."

Borg and Gall (1983) suggest that it is desirable to check a portion of the nonresponding group if more than 20 percent of the questionnaires are not returned. According to Borg and Gall, the general findings from the literature indicate little difference between respondents and nonrespondents if less than 20 percent of the questionnaires are not returned. On the other hand, they suggest that if more than 20 percent are not returned, it is desirable to check a portion of the nonresponding group. The ideal method of checking is to select a small number of cases randomly from the nonresponding group and then "contact" these subjects to determine their reason for "nonresponse." In *this* study, a postcard was mailed to nonrespondents to determine their reasons for "nonresponse."

One factor affecting the response rate is the population being surveyed. In *this* study, members of the AIAA constituted the study population. Historically, surveys of engineers and scientists have yielded low response rates (Citro and Kalton, 1989). For example, the National Science Foundation (NSF) conducted a survey of engineers and scientists in 1982. The sample was mailed a questionnaire and a postcard, and up to two additional questionnaires were sent to the nonrespondents. After the third questionnaire, a telephone follow-up was attempted with the remaining nonrespondents. The response rate for the survey was 71 percent (Citro and Kalton, 1989).

One of the reasons often given to explain why engineers and scientists are difficult to survey is because of the problems in defining who is an engineer or scientist (Citro and Kalton, 1989). Citro and Kalton present additional evidence to show that the response rates for this group have decreased during the 1980's.

Consequently, it was assumed that achieving a response rate of 75 percent or higher would be difficult. It was also assumed that the questionnaires would not be relevant to a certain percentage of the sample. That is, some of the sample would not be actively engaged in aerospace research. Therefore, an overall response rate greater than 75 percent would be difficult to obtain because the salience of the topic was expected to be unrelated to the professional duties of some members of the sample (Heberlein and Baumgartner, 1978).

Dillman's Total Design Method (TDM)

According to Dillman (1978), the process of sending a questionnaire to prospective respondents, getting them to complete the questionnaire in an honest manner, and getting them to return it can be viewed as a special case of "social exchange." The theory of social exchange, as espoused by Blau (1964), Homans (1961), and Thibaut and Kelley (1959), asserts that the actions of individuals are motivated by the return these actions are expected to bring and, in fact, usually do bring from others. According to Dillman, there are three things that must be done to maximize survey response: minimize the **cost** of responding, maximize the **rewards** for doing so, and establish **trust** that those rewards will be delivered.

Dillman (1978) uses social exchange as the theoretical basis for his TDM. Dillman asserts that the TDM can be used to improve both the quality and the quantity

(response rate) of mail questionnaires. Using the TDM, Dillman reports an average response rate of 70 percent from the general public and 77 percent from specialized groups. (It should be noted that these response rates are considerably higher than those reported for the majority of self-administered mail questionnaires.) Dillman reports that there is almost no difference in response rate for questionnaires of various page lengths below 12 pages or about 125 items. Beyond the 12-page length, the response rate begins to fall off. Dillman further reports that, using the TDM, the average item nonresponse rate is 3 to 4 percent, which is rather low for self-administered mail questionnaires.

Dillman (1978) asserts that, using the TDM, a researcher can expect to achieve results that may be comparable in quantity and quality to those obtained through face-to-face interviews at a much lower cost. Dillman offers the following description of the TDM:

> The total design method consists of two parts. The **first** is to identify each aspect of the survey process that may affect either the quality or quantity of response and to shape each of them in such a way that the best possible responses are obtained. The **second** is to organize the survey efforts so that the design intentions are carried out in complete detail. The first step is guided by a theoretical view of why people respond to questionnaires. It provides the rationale for deciding how each aspect, even the seemingly minute ones, should be shaped. The second step is guided by an administrative plan, the purpose of which is to ensure implementation of the survey in accordance with design intentions.

Dillman (1978) claims that researchers can offer few rewards, but that the power to reward is the real key. There are several actions a researcher might do to reward a respondent. **First,** the researcher should act in a positive manner. As such, the researcher should personalize the process by using real signatures, individual

greetings, and individually typed letters. **Second**, the research should give verbal appreciation. This might include a handwritten note indicating "thanks" or "sincere appreciation" to respondents and, in addition, a follow-up postcard thanking respondents for their responses. **Third**, the researcher should use a consulting approach. This means that respondents are told that their views are important and need to be heard. Open-ended questions should be included in the survey to permit respondents to voice their opinions in greater detail. **Fourth**, the researcher should describe to the respondent the social value of the study. For example, the researcher could tell the respondent how the results might be used, the issues involved, and the impact the results might have on the issues. **Fifth**, the researcher must make the questionnaire interesting. The more interesting the questionnaire, the more motivated the respondent becomes to complete and return the instrument. All these actions were taken in *this* study.

Dillman (1978) claims that cost to the respondent, both in terms of money and effort, should be reduced as much as possible. This can be accomplished in several ways. **First**, the instrument can be made clear, concise, and simple by reducing its size and giving it a simple and attractive layout. **Second**, simple directions can be used and complex and difficult questions avoided. **Third**, the possibility of embarrassment can be eliminated by avoiding the inclusion of personal questions. **Fourth**, subordination can be reduced by making the respondents feel as though they are part of the process. **Fifth**, any direct cost can be eliminated by including postage-paid return envelopes and never asking the respondents to bear the cost of postage. All these actions were taken in *this* study.

Dillman (1978) claims that in social exchange there is no way to guarantee that a favor will be returned for a favor. Therefore, one must trust the other person to do something in return for doing something. Trust can be built in several ways. First, the researcher can provide a token of appreciation by offering to send the respondent a copy of the results or by assuring the respondent that the results will find their way to those individuals having the power to do something about the issue. This was done in *this* study. Second, the research should be identified with an organization that has a legitimate interest in the issue. For example, as was done in *this* study, the name of the organization providing the funding was included in the cover letter. If possible, include a letter of endorsement from the funding organization.

Dillman's TDM (1978) advises that the questionnaire should be prepared as a booklet printed on white or off-white paper. In *this* study, some of the questionnaires were printed on light blue and green paper out of necessity. According to Dillman, no questions should be printed on the front page, which is reserved for an interesting title or illustration. In *this* study, the cover contained a graph that plotted U.S. trade surplus for aerospace and agriculture, 1984-1989. Dillman suggests that the more general questions should be placed first, followed by potentially objectionable questions, with demographic questions last. Lowercase letters should be used for the questions; uppercase letters are used for the answers. Questions should not overlap from one page to another, although they did, out of necessity, in the questionnaire used in *this* study.

Each respondent in *this* study was sent a personalized, one-page letter. To ensure a response, the letter explained the social value of the study, why each

respondent's input and response was needed, and who should complete the survey. Each letter contained the typed name and address of the respondent and was printed on official letterhead. The researcher's name was individually signed in blue ink for each letter. Each questionnaire was stamped with an identification number, which was explained in the cover letter, and the mail-out package was placed in an envelope for mailing. The respondent's name and address were typed on the envelope. First-class postage was used to ensure forwarding if the person had moved. (Stamps are preferred to postage meters.) A postcard follow-up reminder was mailed out to all recipients one week after the initial mailing. Three weeks after the initial mailing, a follow-up package was mailed to everyone who had not responded. Three weeks after the second mailing, a follow-up package was sent by registered mail to nonrespondents.

RESEARCH DESIGN

Research design, according to Kerlinger (1986), is the plan and structure of investigation so conceived as to obtain answers to research questions. He further states that the plan is the overall scheme or program of the research. The structure is the framework, organization, or configuration of the elements that compose the study. Furthermore, the structure is a paradigm or model of the relations among the variables in the study. The research design, therefore, "expresses both the structure of the research problem and the plan of investigation used to obtain empirical evidence on the relations of the problem" (Kerlinger, 1986).

Related literature and previous research were identified, reviewed, and analyzed as part of the process of understanding, defining, and establishing a theoretical and

conceptual framework for the problem and of the research described herein. The search for related research and literature included searches of print and computerized data bases, including *Dissertation Abstracts, Engineering Index, Compendex, ERIC, Information Science Abstracts, LISA, NTIS,* and *SCISEARCH*, the *Annual Review of Information Science and Technology* (ARIST), books, periodicals, reports, conference proceedings, encyclopedias, and bibliographies. Several search strategies and topics were used as part of the review of related research and literature. The results of the review of relevant literature and research were used to finalize the overall scope, research questions, assumptions, hypotheses, and research methodology for the study. Three assumptions and research questions, 1 dependent variable, and 13 independent variables were incorporated in the study.

Population and Sample Selection

Stage 1 of the five-stage research design procedure involved identifying the appropriate population. There is no practical way to identify all the aerospace engineers and scientists in the U.S. For this reason, the population for *this* study was identified as the members of the AIAA. The AIAA is the largest American technical society devoted to engineering and science in the fields of aeronautics and astronautics. The sample frame consisted of all AIAA members residing in the U.S. in 1989. The sample frame was compiled from the AIAA National Membership Profile as of January 1989.

In developing the sample frame, the intent was to target and include only those AIAA members whose professional duties are primarily aerospace research. Consequently, non-U.S. addresses were deleted, as were AIAA members with job titles

of students, librarians, and retired members. As Dillman (1978) states, "There is no such thing as a perfect list." The AIAA list had many shortcomings, chief among which was its currency. As was determined from its use, the list contained numerous incorrect addresses and deceased members.

Stage 2 of the five-stage research design procedure involved the creation of the sample. The sample frame consisted of approximately 34 000 AIAA members and excluded all non-U.S. members, retirees, and students. From the sample frame, 6781 persons (about 1 out of every 5) were systematically sampled. A random number was assigned to each of the original 6781 names. The names were sorted by that random number and 2900 names were selected. Some names were deleted, such as those names with a foreign address. The sample was supplemented from the original 6781 to bring the number back to 2900. The process was repeated until a final sample of 2898 was obtained.

Probability sampling, which assumes that each member of the sample frame has a known probability of being included in the sample, was used to assure a representative sampling plan. Probability sampling makes it possible to estimate the extent to which the sample findings are likely to differ from what would have been found by studying the entire population of AIAA members. With probability sampling, it is possible to specify the sample size that is needed to guarantee that the sample findings are fairly close to those that a study of the entire population would yield.

A review of the returned questionnaires indicated that AIAA members with academic affiliations were underrepresented. Academics comprise approximately 15 percent of the AIAA membership; however, academics comprised less than 2 percent

of the returns. A review of the original sample provided by the AIAA indicated that academics were underrepresented. To redress this problem, all names listed with an academic address on the 1989 membership roster (about 1200 names) were entered into a data base, assigned random numbers, and sorted. All faculty members who were in the original sample were deleted.

Questionnaire Development

Stage 3 of the five-stage research design procedure involved developing the questionnaire. The survey instrument consisted of 65 closed-ended and 1 open-ended questions. Questions from previously cited studies concerned with the information-seeking habits and practices of engineers and scientists were used to develop the questions used in *this* study. The questions included in the survey instrument utilized nominal, ordinal, and ratio scales to record the data. To answer most questions, respondents circled a code number or inserted a number in blank lines. The questionnaire was pretested on 3 groups of 25 aerospace engineers and scientists at the NASA Langley Research Center to determine the amount of time required to complete the survey, to ascertain the clarity of the instructions, and to identify any questions that needed modification because of wording or misinterpretation. The questionnaire and associated correspondence are presented in appendix C.

When a sample is randomly selected from a population, the characteristics of the population may reasonably be inferred from the attributes of the sample. Such inference is then subject to various conventions regarding statistical significance. The appropriate application of such conventions to the **primary** survey effort is called **estimation of parameters** (Gravetter and Wallnau, 1985; Hopkins, Glass, and Hopkins,

1987). The population parameters, in *this* study a population parameter **P**, are estimated from the sample statistic **p**. Such estimates are dependent in part upon sample size. The sample sizes vary from question to question because all respondents did not answer each question. However, given the general range of the sample sizes and the nature of the sampling distributions of proportions, it can be stated that at the 95-percent confidence level, the sample statistics **p** of the sample group are within plus or minus 3 percentage points of the population parameter **P**, that is, $\mathbf{p} = \mathbf{P} \pm 3\%$.

Data Collection

Stage 4 of the five-stage research design procedure included the collection of data. The first mailing of questionnaires took place on May 15, 1989. Each member of the sample received a package containing the questionnaire, a cover letter explaining the survey, and a postage-paid envelope. The letter was written on Indiana University (IU) School of Library and Information Science (SLIS) letterhead and was signed by Herbert S. White, dean of the school. A reminder postcard, signed by Dean White, was sent out to all persons in the sample during the first week of June 1989. On June 30, 1990, follow-up letters and questionnaires were sent to those individuals who had not returned the questionnaire. The letter in the second mailing was on IU SLIS letterhead and was signed by Dean White. On August 7, 1989, a third mailing was sent to nonrespondents and included another follow-up letter on IU SLIS letterhead and another copy of the questionnaire.

A supplemental follow-up letter was sent on September 8, 1989. The letter was written on NASA Headquarters letterhead and was signed by Dr. Randolph A. Graves, Director of the Aerodynamics Division. This letter included a postage-paid postcard

on which the respondent could request a new copy of the questionnaire, declare that the study was inappropriate for their duties, refuse to participate in the study, or request a copy of the results. Individuals requesting a copy of the questionnaire were sent a copy of the survey and a short letter, signed by Dr. John M. Kennedy, IU Center for Survey Research, thanking them for their interest.

As previously mentioned, a review of the returned questionnaires indicated that AIAA members with academic affiliations were underrepresented. To redress this problem, 400 faculty names were randomly selected and sent a package on January 2, 1990, containing the questionnaire, a cover letter explaining the survey, and a postage-paid envelope.

The January 2, 1990, mailing contained two explanatory cover letters. One letter was written on NASA letterhead and was signed by Bruce Holmes, Acting Director of the Aerodynamics Division at NASA Headquarters in Washington, DC. The second letter was written on IU Center for Survey Research letterhead and signed by Dr. John M. Kennedy, director. On January 19, 1990, a follow-up letter, signed by Dr. Kennedy, was sent to all nonrespondents as a substitute for a postcard. A second mailing took place on February 2, 1990, and included a follow-up letter signed by Dr. Kennedy.

Including the faculty mailing, the total sample was **n** = 3298. A questionnaire was mailed to everyone in the sample. The actual number of questionnaires received was 2016 for a **62-percent rate of return**. In survey research, it is both reasonable and customary to delete individuals from the sample for reasons such as death, illness, retirement, wrong addresses, and individuals who indicated that the questionnaire was

inappropriate for their present professional duties. Removing these individuals produced an **adjusted n** of 2894. Considering the number of questionnaires returned (2016) and the **adjusted n** of 2894 resulted in an **adjusted response rate of 70 percent.**

The following procedure was undertaken to increase the overall survey response rate and to establish the relevance of the survey focus for the remaining "non-responding" persons in the sample. A letter from Dr. Randolph A. Graves, Director of the Aerodynamics Division at NASA Headquarters, was sent to the remaining non-respondents. The letter (see appendix C) explained the importance of the survey and requested cooperation with the project. Since U.S. aerospace researchers are familiar with NASA, it was assumed that a letter from a NASA division director would induce some of the nonrespondents to complete and return the questionnaire. The impact of a letter from a government sponsor was found previously by Heberlein and Baumgartner (1978) to significantly increase response rates.

In order to identify the relevance of the content of the questionnaires, a return postcard was enclosed with a letter. This postcard allowed the recipient to check off one of the following:

- o Please send me another questionnaire.
- o I am not involved in aerospace research.
- o I do not wish to participate in the study.
- o Please send me a copy of the final report.

The postcard was designed to help determine if the previous nonresponse was due to the content of the questionnaire. It was expected that this procedure would allow a more accurate determination of the proportion of the sample that did not respond because the survey focus was not appropriate to them. Based on the results of the

sponsor letter and postcard, it was assumed that the nonrespondents were probably not involved in research and, therefore, the questionnaire was simply not relevant to these individuals. Based on further analysis of the AIAA sample and the demographics of the respondents, it was concluded that "most" of the AIAA members in the sample doing research returned the questionnaires (Kennedy and Pinelli, 1990).

Data Processing

Stage 5 of the five-stage research design procedure included the processing of the data. A complete record was kept at the Center for Survey Research on all returned questionnaires. Each returned questionnaire was reviewed and examined to ascertain acceptability for processing and to make any corrections or notations that might be required before processing. Once certified for processing, data contained in the questionnaires were transferred (input) to a computer file using previously specified record formats. The transferred data were reviewed, edited, and "cleaned" to ensure acceptability for analysis.

THE FRAMEWORK FOR DATA ANALYSIS

This study has both an immediate and a broader purpose. In the first instance, it provides an empirical basis for understanding the role of the U.S. government technical report in the diffusion of knowledge resulting from federally funded aerospace R&D. In the broader sense, it provides insight regarding the information-seeking habits, practices, needs, and preferences of U.S. aerospace engineers and scientists.

Data collected through the use of a self-administered mail questionnaire were analyzed using the Statistical Package for the Social Sciences-X (SPSS-X) with an IBM-XT. Data concerning the information-seeking habits and practices of U.S. aerospace engineers and scientists, contained in chapter 5, are treated as descriptive data and are presented in terms of academic, government, and industry affiliation. The results of the tests of the eight hypotheses established for the study are contained in chapter 6.

Assumptions

Four assumptions underlie the analysis of the data. The unit of analysis for the dependent variable is the number of times a U.S. government technical report was used in a 6-month period. The fundamental assumption underlying the unit of analysis is that the "number of times used in a 6-month period" represents an unbiased sample; that is, the "number used" would not vary considerably over a substantial period of time. Other assumptions underly the analysis of the data. First, the incidents reported by the respondents were valid. Second, the selection of their most recent problem, task, or problem was reported without bias. Third, the respondents' information use over a 6-month period did not fluctuate dramatically over moderate periods of time.

Data Analysis

Three statistical tests were used to analyze the data collected in *this* study. The chi square test for independence, which provides a standard for deciding whether two variables are statistically independent, was used to test hypotheses 1-7. The chi square is a commonly used nonparametric test of significance for tables containing

nominal and ordinal variables. The chi square test, as applied to the hypotheses in *this* study, consisted of four parts: (1) the alternative hypothesis (H_1) that the variables are statistically dependent, (2) expected frequencies derived under the assumption that the alternative hypothesis is true, (3) a comparison of these expected values with the corresponding observed frequencies, and (4) a judgment as to whether the differences between the expected and observed frequencies could have risen by chance.

The Pearson product-moment correlation, or the Pearson coefficient, was used to test hypothesis 7. The Pearson coefficient is an inferential test, a statistical measure, a number that expresses the strength of the relationship between two variables. Computation of a correlation coefficient indicates how well the data being tested can be described as a linear model. A correlation measures the degree of relationship between two variables on a scale from 0 to 1.00. It does not, however, explain why the two variables are related, nor should it be interpreted as proof of a cause-effect relationship between the two variables.

A one-way analysis of variance (ANOVA) was the inferential statistic used to test certain of the descriptive data reported in chapter 5. Descriptive data were reported in terms of academic, government, and industry affiliation. A one-way ANOVA was used to test for statistical significance among the three groups, that is, AIAA members with either academic, government, or industry affiliation. The ANOVA statistics were adjusted for unequal cell sizes. All statistical differences reported in chapters 5 and 6 are significant at $P \leq 0.05$. Finally, only substantially significant differences (not all statistically significant differences) are reported.

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CHAPTER 5

PRESENTATION OF THE DESCRIPTIVE DATA

INTRODUCTION

This chapter, which contains the descriptive data for the study, contributes to the immediate and broader purposes of the study. First, the U.S. government technical report is viewed in terms of its use within a formal information structure. Second, the U.S. government technical report is viewed in terms of the information-seeking habits and practices of U.S. aerospace engineers and scientists and their use of U.S. government technical reports in problem solving.

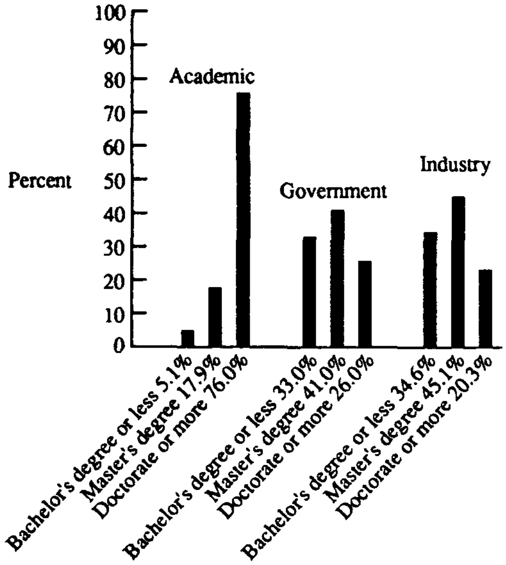
BACKGROUND

The sample frame consists of AIAA members who live in the U.S. Of the 2016 questionnaires received, 1839 were selected for data analysis, presentation, and discussion. The difference of 177 includes retired, unemployed, and AIAA members who selected "other" as their organization affiliation who were eliminated from the sample. The sample of 1839 includes those individuals with an academic, government, industry, or not-for-profit affiliation. For purposes of this research, the not-for-profit respondents have been incorporated with the academic respondents. Sample demographics for these individuals (n=1839) appear in figure 11. A brief discussion of the survey demographics follows.

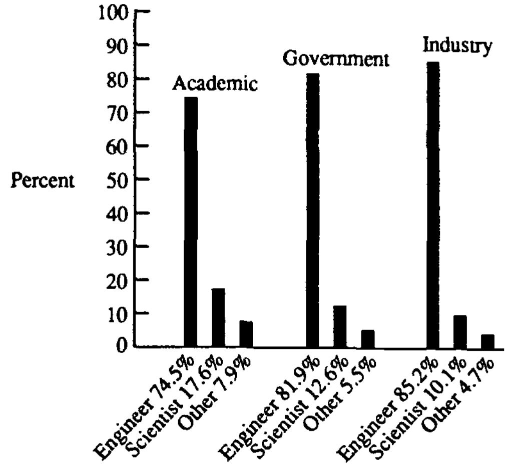
The respondent's highest level of education is presented in figure 11.1. Seventy-six percent of the respondents with an academic affiliation hold at least a doctorate. Education is fairly evenly divided among government-affiliated respondents, with 33 percent having a bachelor's degree or less, 41 percent holding a master's degree, and 26 percent holding a doctorate. About 35 percent of the industry-affiliated respondents have a bachelor's degree or less, about 45 percent hold a master's degree, and about 20 percent possess a doctorate.

Most of the respondents were educated as engineers (figure 11.2). In terms of organizational affiliation, about 75 percent of the academically affiliated respondents were educated as engineers and about 18 percent were educated as scientists. About 82 percent of the government-affiliated respondents were educated as engineers and about 13 percent were educated as scientists. About 8 percent of the academically affiliated respondents were educated as neither engineers nor scientists, and about 6 percent of the government-affiliated respondents were educated as neither engineers nor scientists.

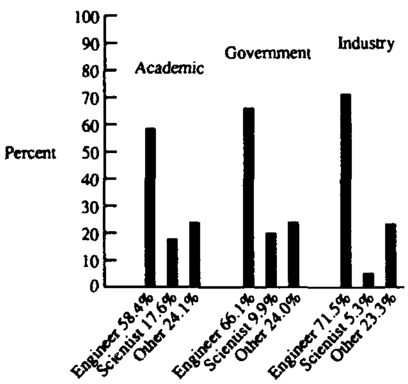
The educational preparation (figure 11.2) and professional duties (figure 11.3) of the respondents vary. In terms of organizational affiliation, about 58 percent of the academically affiliated respondents function as engineers, about 18 percent function as scientists, and about 24 percent function as neither engineers nor scientists. About 66 percent of the government-affiliated respondents function as engineers, about 10 percent function as scientists, and about 24 percent function as neither engineers nor scientists. About 72 percent of the industry-affiliated respondents function as engineers, about 5 percent function



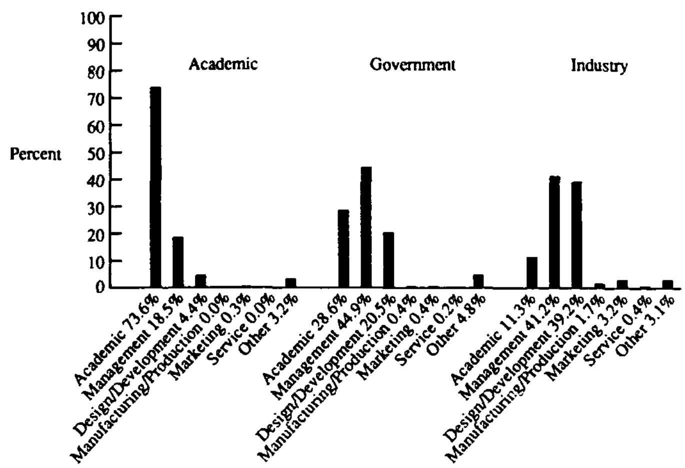
(1) Highest Level of Education.



(2) Educational Preparation.

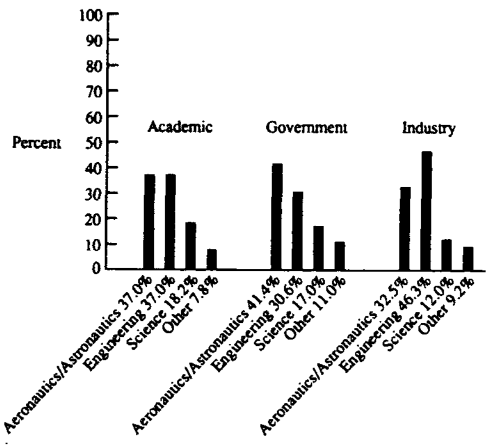


(3) Present Professional Duties.

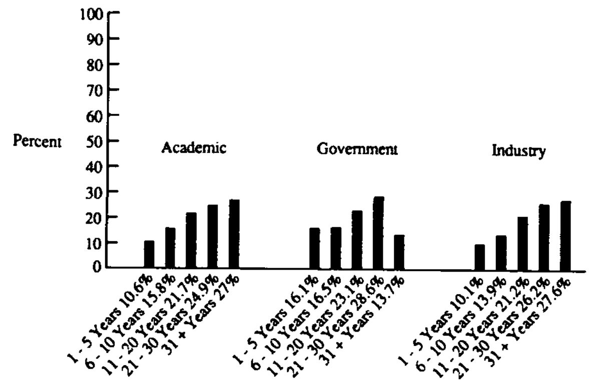


(4) Primary Professional Duties.

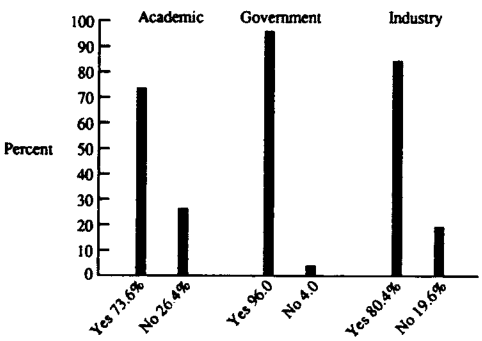
Figure 11. Survey Demographics -- (n=1839).



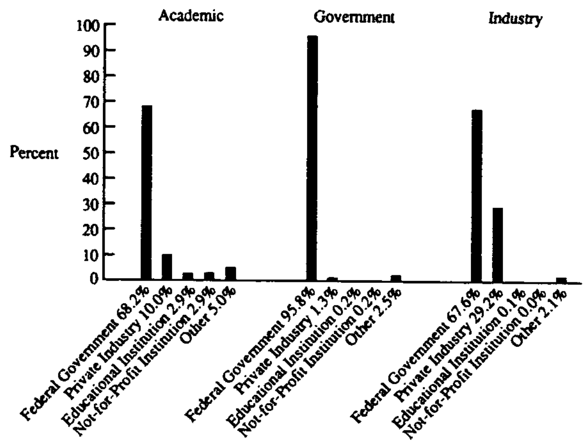
(5) Technical Discipline.



(6) Years of Work Experience.



(7) Federal Funding.



(8) Funding.

Figure 11. Concluded.

as scientists, and about 23 percent function as neither engineers nor scientists. The variations between educational preparation and professional duties are offset by corresponding increases in the category "other."

Respondents perform a narrow range of professional duties (figure 11.4). The majority of the academically affiliated respondents (73.6 percent) perform academic duties, which may include both teaching and research, and about 19 percent perform management duties. About 45 percent of the government-affiliated respondents perform management duties, about 29 percent perform academic duties, and about 21 percent perform design and development duties. About 41 percent of the industry-affiliated respondents perform management duties, about 39 percent perform design and development duties, and about 11 percent perform academic duties.

Aerospace R&D is represented in chapter 1 as a linear process incorporating research, design and development, manufacturing and production, marketing and sales, service, and management. Based on the demographics (figure 11.4), the manufacturing and production, marketing and sales, and service components of the aerospace R&D process appear to be underrepresented.

In terms of technical disciplines, the majority of the respondents are more closely aligned with engineering as opposed to science (figure 11.5). About 82 percent of the academically affiliated respondents are involved in nonscience disciplines. The same holds true for government-affiliated respondents (82 percent) and for industry-affiliated respondents (88 percent). Thirty-seven percent of the academically affiliated respondents selected engineering as their technical discipline,

26.5 percent selected aeronautics, and 10.5 percent selected astronautics as their technical discipline. About 31 percent of the government-affiliated respondents selected engineering as their technical discipline, 30 percent selected aeronautics, and 11.4 percent selected astronautics. About 46 percent of the industry-affiliated respondents selected engineering as their technical discipline, 22.5 percent selected aeronautics, and 10 percent selected astronautics.

About 48 percent of the academically affiliated respondents possess 20 years or less of work experience; about 25 percent possess 21 to 30 years (figure 11.6). Twenty-seven percent have 31 or more years of work experience. About 56 percent of the government-affiliated respondents possess 20 years or less of work experience; about 29 percent possess 21 to 30 years of work experience. About 14 percent have 31 or more years of work experience. About 45 percent of the industry-affiliated respondents have 20 years of work experience or less; about 26 percent have 21 to 30 years. About 28 percent have 31 or more years of work experience.

Respondents were asked if any of their current work is funded by the Federal government (figure 11.7). About 74 percent of the academically affiliated respondents indicated that their work is funded by the Fe[illegible] government. Ninety-six percent of the government-affiliated respondents indicated that some of their work is funded by the Federal government. About 80 percent of the industry-affiliated respondents indicated that some of their work is funded by the Federal government.

Respondents were asked who supplies the largest proportion of funds for their current research or project (figure 11.8). About 68 percent of the academically affiliated respondents, about 96 percent of the government-affiliated respondents, and about 68 percent of the industry-affiliated respondents receive the largest portion of their funding from the Federal government.

FINDINGS

The responses to the 65 closed-ended questions are presented as four study topics. The responses for survey topics 1 and 2 appear in this chapter. The responses for survey topics 3 and 4 appear in appendix E. For each question, the findings are presented in the aggregate and according to organizational (academic, government, and industry) affiliation. Findings pertinent to survey topic 1 are also presented as tables in appendix D according to the highest level of education, defined as bachelor's degree or lower, master's degree, or doctorate or higher; educational preparation, defined as engineer, scientist, or other; and years of professional work experience, defined as 1 to 5 years, 6 to 10 years, 11 to 20 years, 21 to 30 years, and 31 or more years of experience. Findings pertinent to survey topic 2 are also presented in appendix D as tables D25-D32.

Survey Topic 1: The U.S. Government Technical Report Within a Formal Information Structure

Based in large part on the results of the pilot study, the U.S. government report was placed within the context of three technical information products: conference-meeting papers, journal articles, and in-house technical reports. Question

responses were grouped for presentation purposes according to the following four themes: use and importance, factors affecting use, purpose, and information type and product.

Use and Importance. Survey respondents were asked to indicate their use and importance of these four information products and approximately how many times they had used each product in the past 6 months in performing their present professional duties. As shown in table 20, almost all the U.S. aerospace engineers

Table 20. Technical Information Products Used

Information product	Percentage using product in -			Overall percentage using product (n = 1839)[a]
	Academia (n = 341)	Government (n = 454)	Industry (n = 1044)	
Conference-Meeting papers	99.4	99.1	95.5	97.1
Journal articles	99.4	97.4	95.5	96.7
In-house technical reports	97.9	99.6	98.8	98.8
U.S. Government technical reports	98.9	99.1	96.6	96.6

[a]177 of the 2016 total respondents were not included in tables 20-44 because 149 did not specify the type of organization where they worked and 28 were retired or unemployed.

and scientists in this study use the four information products in performing their present professional duties. There is no statistical difference in use among the academically, government-, and industry-affiliated respondents. In terms of highest level of education (table D1), career (table D2), and years of professional work experience (table D3), almost all the respondents use the four information products in performing their present professional duties. There is little difference in the overall use rate for each of the four information products. (See appendix D.)

Using a 5-point scale, survey participants rated the importance of conference-meeting papers, journal articles, in-house technical reports, and U.S. government technical reports (table 21). The rating of 1 to 5 points, very important to very unimportant, used in the survey instrument is reversed for purposes of data analysis, presentation, and discussion. Further, a positive and significant correlation coefficient, shown below, is found when information product use and importance are compared, indicating that those information products considered to be important are also used by survey participants.

	Conference-meeting papers	Journal articles	In-house technical reports	U.S. government technical reports
Correlation coefficient of importance and use	.248	.262	.164	.175

Table 21. Importance of Technical Information Products

Information product	Average[a] (mean) importance rating in -			Overall average (mean) importance rating	Total respondents
	Academia (n = 341)	Government (n = 454)	Industry (n = 1044)	(n = 1839)	
Conference-Meeting papers	4.04	3.64	3.31	3.53	1777[b]
Journal articles	4.35	3.49	3.26	3.52	1775[c]
In-house technical reports	3.02	3.98	4.05	3.84	1766[d]
U.S. Government technical reports	3.45	3.73	3.44	3.51	1778[e]

[a]A 1 to 5 point scale was used to measure importance, with "1" being the lowest possible importance and "5" being the highest possible importance. Hence, the higher the average (mean), the greater the importance of the product. [b]Sixty-two survey participants did not rate the importance of conference-meeting papers. [c]Sixty-four survey participants did not rate the importance of journal articles. [d]Seventy-three survey participants did not rate the importance of in-house technical reports. [e]Sixty-one survey participants did not rate the importance of U.S. Government technical reports.

Of the four information products, the overall mean importance rating is highest for in-house technical reports. The overall mean importance rating, although

lower, does not differ considerably for conference-meeting papers, journal articles, and U.S. government technical reports. Statistically, academically affiliated respondents attribute a higher importance rating to conference-meeting papers and journal articles. Government- and industry-affiliated respondents attribute a higher importance rating to in-house technical reports. (Government-affiliated respondents probably view U.S. government technical reports as being synonymous with in-house technical reports.)

Statistically, participants possessing a doctoral degree or higher (table D4) attribute a higher importance rating to conference-meeting papers and journal articles. In-house technical reports are rated more important by survey participants possessing a bachelor's degree or lower and a master's degree than by those participants possessing a doctoral degree or higher. Scientists rate conference-meeting papers and journal articles more important than do engineers (table D5). Engineers rate in-house technical reports more important than do scientists. Engineers and scientists rate the importance of U.S. government technical reports about equal. With two small exceptions, the importance rating of the four information products increases as years of professional work experience increase (table D6).

Survey participants were asked to indicate the number of times each of the four information products had been used in a 6-month period in the performance of their professional duties (table 22). Data are presented both as means and medians. On the average, in-house technical reports are used to a much greater extent than are the remaining three information products. Conference-meeting papers and journal articles are used to a far greater extent by academically affiliated

participants. In-house technical reports are used to a far greater extent by government- and industry-affiliated participants. Average use of U.S. government technical reports is about equal for all three groups.

Table 22. Frequency of Use of Technical Information Products

Information product	Average number of times (median) product used in 6-month period for respondents in -			Overall average number of times (median) product used (n = 1839)	Total respondents
	Academia (n = 341)	Government (n = 454)	Industry (n = 1044)		
Conference-Meeting papers	17.98 (7.00)	13.41 (4.00)	9.23 (4.00)	12.02 (4.00)	1527[a]
Journal articles	26.60 (10.00)	15.41 (5.00)	9.99 (4.00)	14.74 (5.00)	1503[b]
In-house technical reports	9.22 (5.00)	17.91 (6.00)	23.91 (8.00)	20.30 (6.00)	1535[c]
U.S. Government technical reports	10.01 (5.00)	12.41 (5.00)	11.49 (4.00)	11.45 (5.00)	1495[d]

[a]Note that 312 individuals did not answer the question. [b]Note that 336 individuals did not answer the question. [c]Note that 304 individuals did not answer the question. [d]Note that 344 individuals did not answer the question.

With the exception of in-house technical reports, use of the three remaining information products increases as level of education increases (table D7). Survey participants possessing a doctorate or higher make significantly greater use of conference-meeting papers and journal articles (table D7).

On the average, scientists make greater use of the four information products than do engineers (table D8). Engineers and scientists make about equal use of in-house technical reports. Scientists make greater use of conference-meeting papers and journal articles than do engineers (table D8). There is no increase in the use of the four information products as a function of increased years of professional work experience (table D9).

<u>**Factors Affecting Use**</u>. Survey participants who use the four information products were asked to indicate the extent to which seven sociometric factors influence

their use of these products (tables 23-26). The rating of 1 to 5 points, greatly influenced to not influenced, used in the survey instrument is reversed for purposes of data analysis, presentation, and discussion.

Table 23. Factors Affecting the Use of Conference Papers

Selection factor	Average[a] (mean) influence of factor on use for respondents in -			Overall average (mean) influence of factor (n = 1839)	Total respondents[b]
	Academia (n = 341)	Government (n = 454)	Industry (n = 1044)		
Accessibility	3.94	3.82	3.71	3.79	1551[c]
Ease of use	3.43	3.55	3.37	3.43	1548[d]
Expense	2.63	2.42	2.48	2.50	1547[e]
Familiarity or experience	3.71	3.52	3.52	3.56	1551[f]
Technical quality or reliability	3.84	3.71	3.71	3.74	1552[g]
Comprehensiveness	3.50	3.42	3.32	3.38	1545[h]
Relevance	4.12	4.01	3.90	3.97	1547[i]

[a]A 1 to 5 point scale was used to measure importance, with "1" being the lowest possible importance and "5" being the highest possible importance. Hence, the higher the average (mean), the greater the influence of the factor. [b]Note that 53 individuals did not use conference papers. [c]Note that 235 individuals did not answer this question but should have. [d]Note that 238 individuals did not answer this question but should have. [e]Note that 239 individuals did not answer this question but should have. [f]Note that 235 individuals did not answer this question but should have. [g]Note that 234 individuals did not answer this question but should have. [h]Note that 241 individuals did not answer this question but should have. [i]Note that 239 individuals did not answer this question but should have.

Overall, relevance has the greatest influence ($\bar{X}$=3.97) on the use of conference papers, followed by accessibility ($\bar{X}$=3.79) and technical quality or reliability ($\bar{X}$=3.74). Expense ($\bar{X}$=2.50) exerts the least influence on use. There are no differences by organizational affiliation on these same four factors.

Overall, technical quality or reliability exerts the greatest influence ($\bar{X}$=4.03) on the use of journal articles, followed by accessibility ($\bar{X}$=3.88) and relevance ($\bar{X}$=3.87) (table 24). Expense ($\bar{X}$=2.64) exerts the least influence on use. Also noteworthy is the influence exerted on the use of journal articles by comprehensiveness ($\bar{X}$=3.59), familiarity ($\bar{X}$=3.58), and ease of use ($\bar{X}$=3.51).

Table 24. Factors Affecting the Use of Journal Articles

Selection factor	Average[a] (mean) influence of factor on use for respondents in -			Overall average (mean) influence of factor (n = 1839)	Total respondents[b]
	Academia (n = 341)	Government (n = 454)	Industry (n = 1044)		
Accessibility	4.13	3.86	3.79	3.88	1483[c]
Ease of use	3.68	3.59	3.40	3.51	1503[d]
Expense	2.68	2.58	2.61	2.64	1507[e]
Familiarity or experience	3.86	3.55	3.48	3.58	1509[f]
Technical quality or reliability	4.39	4.04	3.88	4.03	1512[g]
Comprehensiveness	3.93	3.64	3.44	3.59	1504[h]
Relevance	4.15	3.92	3.75	3.87	1505[i]

[a]A 1 to 5 point scale was used to measure importance, with "1" being the lowest possible importance and "5" being the highest possible importance. Hence, the higher the average (mean), the greater the influence of the factor. [b]Note that 61 individuals did not use journal articles. [c]Note that 295 individuals did not answer this question but should have. [d]Note that 275 individuals did not answer this question but should have. [e]Note that 271 individuals did not answer this question but should have. [f]Note that 269 individuals did not answer this question but should have. [g]Note that 266 individuals did not answer this question but should have. [h]Note that 274 individuals did not answer this question but should have. [i]Note that 273 individuals did not answer this question but should have.

In terms of organizational affiliation, technical quality or reliability ($\bar{X}$=4.39) exerts the greatest influence on the use of journal articles by academics, followed by relevance ($\bar{X}$=4.15) and accessibility ($\bar{X}$=4.13). Although not in the same order, the same three factors exert the greatest influence on the use of journal articles by government- and industry-affiliated U.S. aerospace engineers and scientists.

Overall, relevance exerts the greatest influence ($\bar{X}$=4.15) on the use of in-house technical reports by U.S. aerospace engineers and scientists, followed by accessibility ($\bar{X}$=4.01) and familiarity or experience ($\bar{X}$=3.78) (table 25). Expense ($\bar{X}$=2.50) exerted the least influence on use.

Table 25. Factors Affecting the Use of In-House Technical Reports

Selection factor	Average[a] (mean) influence of factor on use for respondents in -			Overall average (mean) influence of factor (n = 1839)	Total respondents[b]
	Academia (n = 341)	Government (n = 454)	Industry (n = 1044)		
Accessibility	3.99	4.05	4.00	4.01	1538[c]
Ease of use	3.59	3.74	3.55	3.61	1537[d]
Expense	2.44	2.52	2.50	2.50	1534[e]
Familiarity or experience	3.69	3.81	3.78	3.78	1536[f]
Technical quality or reliability	3.64	3.87	3.76	3.77	1603[g]
Comprehensiveness	3.46	3.65	3.47	3.51	1600[h]
Relevance	3.87	4.22	4.20	4.15	1597[i]

[a]A 1 to 5 point scale was used to measure importance, with "1" being the lowest possible importance and "5" being the highest possible importance. Hence, the higher the average (mean), the greater the influence of the factor. [b]Note that 22 individuals did not use in-house technical reports. [c]Note that 279 individuals did not answer this question but should have. [d]Note that 280 individuals did not answer this question but should have. [e]Note that 283 individuals did not answer this question but should have. [f]Note that 281 individuals did not answer this question but should have. [g]Note that 214 individuals did not answer this question but should have. [h]Note that 217 individuals did not answer this question but should have. [i]Note that 220 individuals did not answer this question but should have.

In terms of organizational affiliation, accessibility ($\bar{X}$=3.99) exerts the greatest influence on the use of in-house technical reports by academics, followed by relevance ($\bar{X}$=3.87) and familiarity or experience ($\bar{X}$=3.69). Relevance ($\bar{X}$=4.22) followed by accessibility ($\bar{X}$=4.05) and technical quality or reliability ($\bar{X}$=3.87) exerts the greatest influence on the use of in-house technical reports by government-affiliated respondents. Relevance ($\bar{X}$=4.20) followed by accessibility ($\bar{X}$=4.00) and familiarity or experience ($\bar{X}$=3.78) exerts the greatest influence on the use of in-house technical reports by industry-affiliated respondents.

Overall, relevance exerts the greatest influence ($\bar{X}$=3.90) on the use of U.S. government technical reports by U.S. aerospace engineers and scientists, followed by technical quality or reliability ($\bar{X}$=3.73) and accessibility ($\bar{X}$=3.65) (table 26).

Table 26. Factors Affecting the Use of U.S. Government Technical Reports

Selection factor	Average[a] (mean) influence of factor on use for respondents in -			Overall average (mean) influence of factor (n = 1839)	Total respondents[b]
	Academia (n = 341)	Government (n = 454)	Industry (n = 1044)		
Accessibility	3.72	3.81	3.54	3.65	1576[c]
Ease of use	3.36	3.58	3.28	3.38	1573[d]
Expense	2.72	2.47	2.45	2.51	1569[e]
Familiarity or experience	3.62	3.64	3.42	3.52	1575[f]
Technical quality or reliability	3.80	3.77	3.68	3.73	1581[g]
Comprehensiveness	3.57	3.65	3.49	3.55	1514[h]
Relevance	3.87	4.03	3.84	3.90	1577[i]

[a]A 1 to 5 point scale was used to measure importance, with "1" being the lowest possible importance and "5" being the highest possible importance. Hence, the higher the average (mean), the greater the influence of the factor. [b]Note that 44 individuals did not use U.S. Government technical reports. [c]Note that 219 individuals did not answer this question but should have. [d]Note that 222 individuals did not answer this question but should have. [e]Note that 226 individuals did not answer this question but should have. [f]Note that 220 individuals did not answer this question but should have. [g]Note that 214 individuals did not answer this question but should have. [h]Note that 281 individuals did not answer this question but should have. [i]Note that 218 individuals did not answer this question but should have.

In terms of organizational affiliation, relevance ($\bar{X}$=3.87) exerts the greatest influence on the use of U.S. government technical reports by academics, followed by technical quality or reliability ($\bar{X}$=3.80) and accessibility ($\bar{X}$=3.72). Relevance ($\bar{X}$=4.03) followed by accessibility ($\bar{X}$=3.81) and technical quality or reliability ($\bar{X}$=3.77) exerts the greatest influence on the use of U.S. government technical reports by government-affiliated U.S. aerospace engineers and scientists. Relevance ($\bar{X}$=3.84) followed by technical quality or reliability ($\bar{X}$=3.68) and accessibility ($\bar{X}$=3.54) exerts the greatest influence on industry-affiliated survey respondents.

For participants with a bachelor's degree or less, relevance ($\bar{X}$=3.87) followed by technical quality or reliability ($\bar{X}$=3.79) and comprehensiveness ($\bar{X}$=3.64) exerts the greatest influence on use (table D10). For those possessing a master's degree, relevance ($\bar{X}$=3.94) followed by technical quality or reliability ($\bar{X}$=3.79)

and accessibility ($\bar{X}$=3.73) exerts the greatest influence on use (table D10). For survey participants possessing a doctoral degree or higher, relevance ($\bar{X}$=3.86) followed by accessibility ($\bar{X}$=3.66) and technical quality or reliability ($\bar{X}$=3.63) exerts the greatest influence on the use of U.S. government technical reports (table D10). With slight variation in the value of the numbers, relevance, technical quality or reliability, and accessibility influence the use of U.S. government technical reports by engineers and scientists (table D11).

Relevance, accessibility, and technical quality are the factors which influence the use of the four information products. The use of in-house technical reports ($\bar{X}$=4.15), U.S. government technical reports ($\bar{X}$=3.90), and conference-meeting papers ($\bar{X}$=3.97) is influenced by relevance. Journal article use is influenced by technical quality ($\bar{X}$=4.03).

The influence of the seven sociometric variables on the use of U.S. government technical reports by academically, government-, and industry-affiliated respondents was tested using a one-way ANOVA. The test results appear below.

Influence of Seven Sociometric Variables on the Use of
U.S. Government Technical Reports by Survey Respondents

	Accessibility	Ease of Use	Expense	Familiarity	Technical Quality	Comprehensiveness	Relevance
Overall	$\bar{X} = 3.6447$	$\bar{X} = 3.3719$	$\bar{X} = 2.5029$	$\bar{X} = 3.5117$	$\bar{X} = 3.7274$	$\bar{X} = 3.5445$	$\bar{X} = 3.8335$
Academic	$\bar{X} = 3.7192$	$\bar{X} = 3.3562$	$\bar{X} = 2.7197$	$\bar{X} = 3.6151$	$\bar{X} = 3.7966$	$\bar{X} = 3.5719$	$\bar{X} = 3.8673$
Government	$\bar{X} = 3.8131$	$\bar{X} = 3.5815$	$\bar{X} = 2.4696$	$\bar{X} = 3.6392$	$\bar{X} = 3.7694$	$\bar{X} = 3.6472$	$\bar{X} = 4.0316$
Industry	$\bar{X} = 3.5401$	$\bar{X} = 3.2782$	$\bar{X} = 2.4465$	$\bar{X} = 3.4168$	$\bar{X} = 3.6842$	$\bar{X} = 3.4868$	$\bar{X} = 3.8372$

Overall, significant differences exist among the three groups for six of the sociometric variables. No statistical difference exists between academically, government-, and industry-affiliated respondents and the influence of technical quality of their use of U.S. government technical reports. This would seem to indicate that the three groups rate the technical quality of U.S. government technical reports high.

Statistically significant differences exist between government- and industry-affiliated respondents and government- and academically affiliated respondents in terms of accessibility, ease of use, and familiarity and their influence on the use of U.S. government technical reports. Statistically significant differences exist between academically and industry-affiliated respondents and academically and government-affiliated respondents in terms of expense and its influence of the use of U.S. government technical reports. Government-affiliated respondents are significantly different from industry-affiliated respondents in terms of the influence of comprehensiveness on the use of U.S. government technical reports. They are also significantly different from academically and industry-affiliated respondents in terms of the influence of relevance on the use of U.S. government technical reports.

Purpose. To help define the role of the U.S. government technical report within a formal information structure, survey respondents were asked to indicate what percentage of the conference-meeting papers, journal articles, in-house technical reports, and U.S. government technical reports the use are for purposes of education, research, management, and other. Overall, conference-meeting papers are used most often for research, followed by education and management (table 27).

Table 27. Use of Conference-Meeting Papers

Purpose	Average percentage of use for respondents in -			Overall average percentage of use (n = 1839)	Total respondents[a]
	Academia (n = 341)	Government (n = 454)	Industry (n = 1044)		
Education	20.16	25.27	25.41	24.23	1355[b]
Research	70.37	50.09	47.86	53.34	1355[c]
Management	6.05	17.62	18.16	15.38	1355[d]
Other	3.41	7.02	8.57	7.05	1355[e]

[a]Note that 67 individuals did not use conference-meeting papers in the past 6 months and that 417 individuals did not answer the question. [b]Includes 509 individuals who used conference-meeting papers "0" percent of the time for that purpose. [c]Includes 228 individuals who used conference-meeting papers "0" percent of the time for that purpose. [d]Includes 838 individuals who used conference-meeting papers "0" percent of the time for that purpose. [e]Includes 457 individuals who used conference-meeting papers "0" percent of the time for that purpose.

About 74 percent of the conference-meeting papers used by survey participants working as scientists are used for research, and about 55 percent of the conference-meeting papers used by survey participants working as engineers are used for research (table D14). It is worthy of note that as years of professional work experience increase, use of conference-meeting papers for purposes of education and research decreases (table D15). Use of conference-meeting papers for purposes of management increases as years of professional work experience increase (table D15).

Overall, journal articles are used most often for research, followed by education and management. Overall, journal articles are used about 52 percent of the time for research (table 28).

Table 28. Use of Journal Articles

Purpose	Average percentage of use for respondents in -			Overall average percentage of use	Total respondents[a]
	Academia (n = 341)	Government (n = 454)	Industry (n = 1044)	(n = 1839)	
Education	23.09	29.76	28.86	27.80	1327[b]
Research	69.14	49.41	45.60	51.83	1327[c]
Management	5.27	14.04	16.22	13.22	1327[d]
Other	2.50	6.79	9.32	7.15	1327[e]

[a]Note that 73 individuals did not use journal articles in the past 6 months and that 439 individuals did not answer the question. [b]Includes 457 individuals who used journal articles "0" percent of the time for that purpose. [c]Includes 218 individuals who used journal articles "0" percent of the time for that purpose. [d]Includes 868 individuals who used journal articles "0" percent of the time for that purpose. [e]Includes 1080 individuals who used journal articles "0" percent of the time for that purpose.

Statistically, survey participants possessing a doctorate or higher make greater use of journal articles than do participants with a master's degree or less. About 72 percent of the journal articles used by survey participants working as scientists are used for research, and about 53 percent of the journal articles used by survey participants working as engineers are used for research (table D17). As years of professional work experience increase, use of journal articles for purposes of education and research decreases (table D18). Use of journal articles for management increases as years of professional work experience increase (table D17).

In-house technical reports are used most often for research (52.86 percent), followed by management (21.54 percent) and education (16.20 percent) (table 29). Academic participants use in-house reports most often for research followed by education and management. Government and industry respondents use in-house technical reports most often for research, followed by management and education.

Table 29. Use of In-House Technical Reports

Purpose	Average percentage of use for respondents in -			Overall average percentage of use	Total respondents[a]
	Academia (n = 341)	Government (n = 454)	Industry (n = 1044)	(n = 1839)	
Education	14.76	18.20	15.61	16.20	1349[b]
Research	66.94	50.73	50.38	52.86	1349[c]
Management	11.70	23.73	22.94	21.54	1349[d]
Other	6.70	7.33	11.07	9.39	1349[e]

[a]Note that 30 individuals did not use in-house technical reports in the past 6 months and that 460 individuals did not answer the question. [b]Includes 678 individuals who used in-house technical reports "0" percent of the time for that purpose. [c]Includes 242 individuals who used in-house technical reports "0" percent of the time for that purpose. [d]Includes 719 individuals who used in-house technical reports "0" percent of the time for that purpose. [e]Includes 1047 individuals who used in-house technical reports "0" percent of the time for that purpose.

About 71 percent of the in-house technical reports used by survey participants working as scientists are used for research, and about 57 percent of the in-house technical reports used by survey participants working as engineers are used for research (table D20). As years of professional work experience increase, use of in-house technical reports for purposes of education and research decreases (table D21). Use of in-house technical reports for management increases as years of professional work experience increase (table D21).

Overall, U.S. government technical reports are used most often for research, followed by education and management. Overall, U.S. government technical reports are used about 56 percent of the time for research (table 30).

Table 30. Use of U.S. Government Technical Reports

Purpose	Average percentage of use for respondents in -			Overall average percentage of use (n = 1839)	Total respondents[a]
	Academia (n = 341)	Government (n = 454)	Industry (n = 1044)		
Education	17.04	18.79	18.11	18.09	1332[b]
Research	70.50	52.60	52.18	55.89	1332[c]
Management	7.71	20.09	19.25	17.22	1332[d]
Other	4.75	8.52	10.47	8.80	1332[e]

[a]Note that 55 individuals did not use U.S. Government technical reports in the past 6 months; 452 individuals did not answer the question. [b]Includes 656 individuals who used U.S. Government technical reports "0" percent of the time for that purpose. [c]Includes 209 individuals who used U.S. Government technical reports "0" percent of the time for that purpose. [d]Includes 803 individuals who used U.S. Government technical reports "0" percent of the time for that purpose. [e]Includes 1046 individuals who used U.S. Government technical reports "0" percent of the time for that purpose.

Academically affiliated participants use U.S. government technical reports most often for research (70.5 percent), followed by education and management. Government- and industry-affiliated respondents use U.S. government technical reports about 52 percent of the time for research, followed by management and education.

About 72 percent of the U.S. government technical reports used by survey participants working as scientists are used for research, and about 59 percent of the U.S. government technical reports are used by survey participants working as engineers for research (table D23). Survey participants working as engineers make greater use of U.S. government technical reports for education (18.93 percent) than do those participants working as scientists (13.89) (table D23). As years of professional work experience increase, use of U.S. government technical reports for purposes of education and research decreases (table D24). Use of U.S. government technical reports for management increases as years of professional work experience increase (table D24).

Overall, over 50 percent of the four information products are used for research purposes. Within academia, about 70 percent of the products are used for research purposes. Conference-meeting papers, journal articles, and U.S. government technical reports are next used for educational followed by management purposes. In-house technical reports are used for management followed by educational purposes.

Information Type and Product. Having explored the use of the four information products for purposes of education, research, management, and other, data regarding the use of five types of technical information were collected. The intent was to explore relationships thought to exist between five types of technical information and the four information products. The selection of the five types of technical information was based in large part on the results of the pilot study.

Survey participants were asked to indicate the types of technical information used in performing their present professional duties. Overall, respondents use basic scientific and technological (S&T) information, followed by in-house technical data and computer programs (table 31).

Table 31. Types of Technical Information Used

Types of technical information	Percentage of each type of information used by respondents in -			Overall percentage of use (n = 1839)
	Academia (n = 341)	Government (n = 454)	Industry (n = 1044)	
Basic scientific and technological information	90.3	85.0	78.6	82.4
In-house technical data	58.1	83.3	83.2	78.6
Computer programs	58.9	59.5	63.0	61.4
Technical specifications	40.8	57.7	67.9	60.4
Product and performance characteristics	42.8	52.4	69.3	60.2

Academic participants make greater use of basic S&T information than do their government and industry counterparts. Government- and industry-affiliated respondents make greater use of in-house technical data. Industry-affiliated respondents make greater use of product and performance characteristics information than do their academic and government counterparts.

Next, survey participants were asked to indicate the percentage of the five types of information found in the four information products. Overall, S&T information is about evenly divided among conference-meeting papers, journal articles, in-house technical reports, and U.S. government technical reports (table 32). For academics, about 68 percent of the basic S&T information they use is found in journal articles and conference-meeting papers. For government-affiliated respondents, the basic S&T information is about evenly distributed among the four information products. About 35 percent of the basic S&T information used by industry-affiliated participants is obtained from in-house technical reports.

Table 32. Sources of Basic Scientific and Technological Information

Information product	Average percentage found in information product by respondents in -			Overall average percentage of use	Total respondents[a] (n = 1839)
	Academia	Government	Industry		
Conference-Meeting papers	27.29	21.56	19.38	21.54	1515[b]
Journal articles	40.86	23.06	18.98	24.47	1515[c]
In-house technical reports	13.39	25.76	34.55	28.01	1515[d]
U.S. Government technical reports	13.98	20.85	17.74	17.77	1515[e]

[a]Note that 324 individuals did not use basic scientific and technological information in the past 6 months. [b]Includes 276 individuals who found basic scientific and technological information in conference-meeting papers "0" percent of the time. [c]Includes 253 individuals who found basic scientific and technological information in journal articles "0" percent of the time. [d]Includes 303 individuals who found basic scientific and technological information in in-house technical reports "0" percent of the time. [e]Includes 328 individuals who found basic scientific and technological information in U.S. government technical reports "0" percent of the time.

Overall, respondents obtain about 46 percent of the basic S&T information they use from in-house and U.S. government technical reports. About 68 percent of the basic S&T information used by academics is obtained from conference-meeting papers and journal articles. Government-affiliated participants obtain about 45 percent of the basic S&T information they use from conference-meeting papers and journal articles and about 46 percent from both government and in-house technical reports. Industry-affiliated respondents obtain about 35 percent of the basic S&T information they use from in-house technical reports.

Overall, respondents obtain about 60 percent of the in-house technical data they use from in-house technical reports (table 33). Industry-affiliated respondents obtain about 67 percent of their in-house technical data from in-house technical reports. Government-affiliated participants obtain about 52 percent of the in-house technical data they use from in-house technical reports. Academics obtain about 46 percent of the in-house technical data they use from in-house technical reports.

Table 33. Sources of In-House Technical Data

Information product	Average percentage found in information product by respondents in -			Overall average percentage of use	Total respondents[a] (n = 1839)
	Academia	Government	Industry		
Conference-Meeting papers	16.74	11.55	8.65	10.52	1445[b]
Journal articles	19.39	9.08	7.33	9.44	1445[c]
In-house technical reports	46.16	52.36	66.71	60.14	1445[d]
U.S. Government technical reports	11.15	18.98	10.04	12.53	1445[e]

[a]Note that 394 individuals did not use in-house technical data in the past 6 months. [b]Includes 716 individuals who found in-house technical data in conference-meeting papers "0" percent of the time. [c]Includes 776 individuals who found in-house technical data in journal articles "0" percent of the time. [d]Includes 77 individuals who found in-house technical data in in-house technical reports "0" percent of the time. [e]Includes 705 individuals who found in-house technical data in U.S. government technical reports "0" percent of the time.

Respondents obtain about 49 percent of the computer programs they use from in-house technical reports (table 34). About 58 percent of the computer programs used by industry-affiliated respondents are found in in-house technical reports. About 40 and 31 percent, respectively, of the computer programs used by government and academic respondents are obtained from in-house technical reports.

Table 34. Sources of Computer Programs

Information product	Average percentage found in information product by respondents in -			Overall average percentage of use	Total respondents[a] (n = 1839)
	Academia	Government	Industry		
Conference-Meeting papers	17.15	11.61	7.29	10.08	1129[b]
Journal articles	20.85	13.19	9.96	12.47	1129[c]
In-house technical reports	31.00	40.08	58.29	49.42	1129[d]
U.S. Government technical reports	12.27	20.06	11.26	13.54	1129[e]

[a]Note that 710 individuals did not use computer programs in the past 6 months. [b]Includes 713 individuals who found computer programs in conference-meeting papers "0" percent of the time. [c]Includes 670 individuals who found computer programs in journal articles "0" percent of the time. [d]Includes 212 individuals who found computer programs in-house technical reports "0" percent of the time. [e]Includes 622 individuals who found computer programs in U.S. government technical reports "0" percent of the time.

Overall, about 75 percent of the technical specifications used by survey participants are obtained from in-house (44 percent) and U.S. government technical reports (31 percent) (table 35). About 70 percent of the technical specifications used by academics are obtained from journal articles (16 percent), in-house technical reports (26 percent), and U.S. government technical reports (28 percent). About 74 percent of the technical specifications used by government-affiliated respondents are obtained from in-house technical reports (43 percent) and U.S. government technical reports (31 percent). About 49 percent of the technical specifications used by industry-affiliated respondents are obtained from in-house technical reports.

Table 35. Sources of Technical Specifications

Information product	Average percentage found in information product by respondents in -			Overall average percentage of use	Total respondents[a] (n = 1839)
	Academia	Government	Industry		
Conference-Meeting papers	14.33	7.57	4.65	6.55	1110[b]
Journal articles	16.27	7.31	5.53	7.30	1110[c]
In-house technical reports	26.20	42.81	48.54	44.39	1110[d]
U.S. Government technical reports	28.24	31.18	31.29	30.88	1110[e]

[a]Note that 729 individuals did not use technical specifications in the past 6 months. [b]Includes 773 individuals who found technical specifications in conference-meeting papers "0" percent of the time. [c]Includes 780 individuals who found technical specifications in journal articles "0" percent of the time. [d]Includes 211 individuals who found technical specifications in-house technical reports "0" percent of the time. [e]Includes 337 individuals who found technical specifications in U.S. government technical reports "0" percent of the time.

About 62 percent of the product and performance characteristics used by survey participants are obtained from in-house technical reports (43 percent) and U.S. government technical reports (19 percent) (table 36). About 65 percent of the

Table 36. Sources of Product and Performance Characteristics

Information product	Average percentage found in information product by respondents in -			Overall average percentage of use	Total respondents[a] (n = 1839)
	Academia	Government	Industry		
Conference-Meeting papers	15.22	10.36	9.12	10.19	1107 [b]
Journal articles	22.09	15.95	12.15	14.28	1107 [c]
In-house technical reports	22.37	35.37	49.38	42.81	1107 [d]
U.S. Government technical reports	21.60	22.53	17.07	18.84	1107 [e]

[a]Note that 732 individuals did not use product and performance characteristics in the past 6 months. [b]Includes 600 individuals who found product and performance characteristics in conference-meeting papers "0" percent of the time. [c]Includes 565 individuals who found product and performance characteristics in journal articles "0" percent of the time. [d]Includes 206 individuals who found product and performance characteristics in in-house technical reports "0" percent of the time. [e]Includes 457 individuals who found product and performance characteristics in U.S. government technical reports "0" percent of the time.

product and performance characteristics used by academics are obtained from journal articles (22 percent), in-house technical reports (22 percent), and U.S. government technical reports (21 percent). About 58 percent of the product and performance characteristics used by government-affiliated respondents are obtained from in-house

technical reports (35 percent) and U.S. government technical reports (23 percent). About 66 percent of the product and performance characteristics used by industry-affiliated respondents are obtained from in-house technical reports (49 percent) and from U.S. government technical reports (17 percent).

Overall, about 82 and 79 percent, respectively, of the survey participants use basic S&T information and in-house technical data in performing their present professional duties. Overall, about 60 percent of the survey participants use computer programs, technical specifications, and product and performance characteristics. Overall, in terms of type of technical information and technical information product, basic S&T information is found more or less evenly distributed throughout the four information products. Most of the in-house technical data, computer programs, technical specifications, and product and performance characteristics are found in in-house and U.S. government technical reports.

Survey Topic 2: The U.S. Government Technical Report and the Information-Seeking Habits and Practices of U.S. Aerospace Engineers and Scientists

Based in large part on the results of the pilot study, the U.S. government technical report was viewed in terms of the information-seeking habits and practices of U.S. aerospace engineers and scientists and their use of U.S. government technical reports in problem solving. Question responses were grouped according to the following four themes: project, task, or problem type; information sources and

Table 37. Type of Most Important Technical Project, Task, or Problem

Type	Number (percentage) responding in -			Total[a] respondents (n = 1749)
	Academia (n = 326)	Government (n = 433)	Industry (n = 990)	
Educational	36 (11.0)	13 (3.0)	21 (2.1)	70 (4.0)
Research	229 (70.2)	172 (39.7)	219 (22.1)	620 (35.7)
Design	12 (3.7)	61 (14.1)	256 (25.9)	329 (18.6)
Development	24 (7.4)	78 (18.0)	274 (27.7)	376 (21.5)
Manufacturing	8 (0.6)	0 (0.0)	15 (1.5)	17 (1.0)
Production	3 (0.9)	9 (2.1)	23 (2.3)	35 (2.0)
Management	13 (4.0)	80 (18.5)	126 (12.7)	219 (12.5)
Computer applications	7 (2.1)	20 (4.6)	56 (5.7)	83 (4.7)

[a]Note that 90 individuals did not answer this question but should have.

project, task, or problem completion; information source sequence; and U.S. government technical reports and project, task, or problem completion.

<u>Project, Task, or Problem Type.</u> Survey participants were asked to describe the most important technical project, task, or problem they had worked on in the past 6 months. As shown in table 37, the majority of the projects, tasks, or problems were identified as either basic or applied research (35.7 percent), development (21.5 percent), and design (18.6 percent). For academically affiliated respondents, the majority of the projects, tasks, or problems were research (70.2 percent), educational (11.0 percent), development (7.4 percent), and design (3.7 percent) in nature.

For government-affiliated participants, about 40 percent of the projects, tasks, or problems were research, 18 percent were development, and about 19 percent were management. For industry-affiliated respondents, about 28 percent were development, about 26 percent were design, about 22 percent were research, and about 13 percent were management.

Information Use and Sequence. The steps followed in searching for the information used by U.S. aerospace engineers and scientists to complete their most important technical project or task or to solve their most important technical problem in the past 6 months were determined. Survey participants were given a list of nine information sources and were asked to identify the steps followed (sources used) in looking for the information needed to complete the project or task or to solve the problem. Survey respondents were instructed to enter "1" beside the first step, "2" beside the second step, and so forth. Tables D25, D26, D27, D28, D29, D30, D31, and D32, respectively, summarize the responses of all, academically affiliated, government-affiliated, industry-affiliated, engineers, scientists, management, and nonmanagement respondents to this question. These tables appear in appendix D.

The data contained in tables D25-D32 were used to produce the weighted average rankings presented in tables 38-41. Weighted average rankings were calculated to determine the actual steps followed (sequence in which information sources were used) by survey respondents to acquire the information needed or used to complete their most important project or task or to solve their most important technical problem in the past 6 months.

The weighted average rankings were obtained by assigning weights based on specific order of use. A weight of 9 was assigned for the step used or followed first, 8 for the step used or followed second, decreasing sequentially to 1 for the step used ninth. The weighted ranking was calculated by the formula $\frac{\sum n_i w_i}{n_t}$ where n_i was the number of participants using a particular information source in the "ith" position, w_i was the weight assigned for the "ith" position, and n_t was the total number of participants who used that particular information source in any position. The weighted average rankings were calculated for all survey respondents; for academically, government-, and industry-affiliated respondents; for engineers and scientists; and for managers and nonmanagers.

As shown in table 38, U.S. aerospace engineers and scientists place high value on the information stored around them and on informal communications. Further, their approach to completing technical projects or tasks or to solving problems involves personal contact with a variety of people. It is not until they have exhausted their personal store of information and have consulted various individuals that U.S. aerospace engineers and scientists turn to formal information sources such as librarians and data bases. This finding is in keeping with previous engineering information use studies. It appears that the participants in this study rarely find all the information they need in one source. Also, they appear to approach the formal system only after having discussed their project, task, or problem with colleagues.

Table 38. Order in Which Information Sources Were Used by Survey Respondents to Complete Most Important Technical Project, Task, or Problem

Overall (n = 1683)		
Steps followed	n	Weighted avg. rank[a]
Used personal store of technical information	1483	7.59
Discussed problem with a colleague in my organization	1344	7.11
Discussed problem with a key person in the organization	1007	6.89
Discussed problem with my supervisor	838	6.68
Intentionally searched library resources	1152	6.16
Searched data base or had data base searched	898	6.13
Discussed problem with a colleague outside the organization	937	6.01
Asked a librarian in the organization	607	5.27
Asked a librarian outside the organization	409	4.12

[a]Highest number indicates step was used first; lowest number indicates step was used last.

The steps followed in searching for the information used by U.S. aerospace engineers and scientists to complete their most important technical project or task or to solve their most important technical problem in the past 6 months were determined for academically, government-, and industry-affiliated respondents (table 39).

Table 39. Order in Which Information Sources Were Used by Academically, Government-, and Industry-Affiliated Respondents to Complete Most Important Technical Project, Task, or Problem

Academia (n = 341)			Government (n = 454)			Industry (n = 1044)		
Steps followed	n	Weighted avg. rank[a]	Steps followed	n	Weighted avg. rank[a]	Steps followed	n	Weighted avg. rank[a]
Used personal store of technical information	257	7.79	Used personal store of technical information	353	7.27	Used personal store of technical information	777	7.57
Discussed problem with a colleague in my organization	197	7.14	Discussed problem with a colleague in my organization	329	7.22	Discussed problem with a colleague in my organization	726	7.05
Intentionally searched library resources	218	7.04	Discussed problem with a key person in the organization	249	6.96	Discussed problem with a key person in the organization	589	6.95
Searched data base or had data base searched	146	6.70	Discussed problem with my supervisor	226	6.88	Discussed problem with my supervisor	476	6.79
Discussed problem with a colleague outside the organization	135	6.32	Discussed problem with a colleague outside the organization	239	5.94	Asked a librarian outside the organization	474	6.07
Asked a librarian in the organization	87	6.08	Intentionally searched library resources	271	5.89	Discussed problem with a colleague outside the organization	486	5.99
Discussed problem with my supervisor	80	5.98	Searched data base or had data base searched	214	5.46	Intentionally searched library resources	586	5.94
Discussed problem with a key person in the organization	108	5.39	Asked a librarian in the organization	149	5.33	Asked a librarian in the organization	331	4.93
Asked a librarian outside the organization	45	4.16	Asked a librarian outside the organization	104	3.46	Searched data base or had data base searched	220	4.25

[a]Highest number indicates step was used first; lowest number indicates step was used last.

In an organizational context, survey participants share certain of the characteristics common to the overall response. Use of personal store of technical information and collegial discussions are common to both. With minor exception, asking a librarian both inside and outside of the organization ranks last as part of the overall search strategy. There are some interesting differences between the three groups, however.

Academically affiliated respondents make contact with the formal system much earlier in the process than either the government- or industry-affiliated respondents. They also search or have a data base searched much earlier in the process. Industry-affiliated respondents appear to consult a librarian outside of the organization before consulting a librarian from within the organization.

The steps followed in the search for information were examined from the standpoint of educational preparation as either an engineer or a scientist (table 40).

Table 40. Order in Which Information Sources Were Used by Engineers and Scientists to Complete Most Important Technical Project, Task, or Problem

Engineers (n = 1627)			Scientists (n = 235)		
Steps followed	n	Weighted avg. rank[a]	Steps followed	n	Weighted avg. rank[a]
Used personal store of technical information	1212	7.51	Used personal store of technical information	180	7.33
Discussed problem with a colleague in my organization	1098	7.15	Discussed problem with a colleague in my organization	161	7.03
Discussed problem with a key person in the organization	839	6.86	Discussed problem with a key person in the organization	106	6.73
Discussed problem with my supervisor	709	6.74	Intentionally searched library resources	146	6.57
Intentionally searched library resources	942	6.06	Discussed problem with my supervisor	82	6.38
Discussed problem with a colleague outside the organization	769	6.02	Searched data base or had data base searched	109	6.35
Searched data base or had data base searched	739	6.01	Discussed problem with a colleague outside the organization	105	6.19
Asked a librarian in the organization	499	5.29	Asked a librarian in the organization	73	5.15
Asked a librarian outside the organization	336	3.99	Asked a librarian outside the organization	49	4.64

[a]Highest number indicates step was used first; lowest number indicates step was used last.

In terms of educational preparation, U.S. aerospace engineers and scientists share characteristics common to the overall response. Both use personal stores of technical information and collegial discussions. Asking a librarian either inside or outside of the organization ranks last in the overall information search strategy. The engineers and scientists are a relatively homogeneous group. With few exceptions, the steps used to acquire information are fairly uniform for both groups.

The steps followed in the search for information were examined from the standpoint of professional duties as either a manager or nonmanager (table 41).

Table 41. Order in Which Information Sources Were Used by Managers and Nonmanagers to Complete Most Important Technical Project, Task, or Problem

Managers (n = 735)			Nonmanagers (n = 1139)		
Steps followed	n	Weighted avg. rank[a]	Steps followed	n	Weighted avg. rank[a]
Used personal store of technical information	542	7.36	Used personal store of technical information	859	7.61
Discussed problem with a colleague in my organization	512	7.11	Discussed problem with a colleague in my organization	761	7.10
Discussed problem with a key person in the organization	434	7.07	Discussed problem with my supervisor	488	6.96
Discussed problem with a colleague outside the organization	413	6.32	Discussed problem with a key person in the organization	519	6.74
Discussed problem with my supervisor	307	6.31	Intentionally searched library resources	715	6.39
Searched data base or had data base searched	352	6.17	Searched data base or had data base searched	500	6.09
Intentionally searched library resources	385	5.72	Discussed problem with a colleague outside the organization	470	5.83
Asked a librarian in the organization	225	5.19	Asked a librarian in the organization	348	5.39
Asked a librarian outside the organization	158	4.01	Asked a librarian outside the organization	221	4.04

[a]Highest number indicates step was used first; lowest number indicates step was used last.

Managers and nonmanagers share certain of the characteristics common to all respondents. Use of personal store of technical information and collegial discussions are common to both. Asking a librarian either inside or outside of the organization ranks last for both groups as part of the overall information search strategy. Perhaps understandably, nonmanagers consult a supervisor before managers and mangers seek outside assistance earlier in the search process than do nonmanagers.

<u>U.S. Government Technical Reports and Project, Task, or Problem Completion</u>. Overall, about 64 percent of the respondents used U.S. government technical reports in completing their most important technical project or task, or in solving their most important technical problem (table 42). Seventy-six percent of the government-affiliated participants used U.S. government technical reports, followed by academic (60.7 percent) and industry affiliates (59.5 percent).

Table 42. Use of U.S. Government Technical Reports in Completing Most Important Technical Project, Task, or Problem

Use	Number (percentage) respondents in -			Total respondents (n = 1839)
	Academia (n = 341)	Government (n = 454)	Industry (n = 1044)	
Yes	207 (60.7)	345 (76.0)	621 (59.5)	1173 (63.8)
No	134 (39.3)	109 (34.0)	423 (40.5)	666 (36.2)

Survey participants were asked how they found out about the U.S. government technical reports they used in completing their most important technical project or task or in solving their most important technical problem (table 43). Survey participants were **not asked** to indicate the order (the steps) in which the sources were used. Percentages of use were calculated for all survey respondents; for academically, government-, and industry-affiliated respondents; for engineers and scientists; and for managers and nonmanagers. The information sources used by survey respondents to find out about U.S. government technical reports were compared with the information sources used to complete their most important technical project or task or in solving their most important technical problem.

Table 43. Sources Used by Survey Respondents to Find Out About U.S. Government Technical Reports Used to Complete Most Important Technical Project, Task, or Problem

Overall (n = 2016)[a]		
Source	n	Percentage who used
Used personal store of technical information	1026	83.1
Asked a colleague in my organization	712	57.7
Asked a colleague outside of my organization	616	49.9
Intentionally searched library resources	613	49.7
Asked a librarian	376	30.5
Searched data base or had a data base searched	547	27.1
By accident, browsing, or looking for other material	323	26.2
Someone informed me without my asking	294	23.8
Asked my supervisor	281	22.8

[a]Note that 746 individuals did not use U.S. Government technical reports and that 36 individuals did not answer the entire question.

The information sources used by survey participants to locate U.S. government technical reports are similar to those used for completing their most important technical project, task, or problem. In both cases, survey respondents place a high value on the information stored around them and on informal communications.

The information sources used by survey participants to find out about U.S. government technical report were determined from the standpoint of academic, gov-

ernment, and industry affiliation (table 44). Regardless of organizational affiliation, the U.S. aerospace engineers and scientists in this study display a preference for

Table 44. Sources Used by Academically, Government-, and Industry-Affiliated Respondents to Find Out About the U.S. Government Technical Reports Used to Complete Most Important Technical Project, Task, or Problem

Academia (n = 341)[a]			Government (n = 454)[b]			Industry (n = 1044)[c]		
Source	n	Percentage who used	Source	n	Percentage who used	Source	n	Percentage who used
Used personal store of technical information	173	84.0	Used personal store of technical information	298	88.4	Used personal store of technical information	479	80.0
Intentionally searched library resources	117	56.8	Asked a colleague in my organization	229	68.0	Asked a colleague in my organization	352	58.8
Asked a colleague outside of my organization	111	53.9	Asked a colleague outside of my organization	172	51.0	Asked a colleague outside of my organization	284	47.4
Asked a colleague in my organization	87	42.2	Intentionally searched library resources	172	51.0	Intentionally searched library resources	278	46.4
Searched data base or had a data base searched	86	41.7	Searched data base or had a data base searched	159	47.2	Searched data base or had a data base searched	262	43.7
Asked a librarian	61	29.6	Asked a librarian	109	32.3	Asked a librarian	174	29.0
By accident, browsing, or looking for other material	56	27.2	Asked my supervisor	89	26.4	By accident, browsing, or looking for other material	153	25.5
Someone informed me without my asking	46	22.3	By accident, browsing, or looking for other material	89	26.4	Asked my supervisor	147	24.5
Asked my supervisor	27	13.1	Someone informed me without my asking	78	23.1	Someone informed me without my asking	146	24.4

[a]Note that 134 individuals did not use U.S. Government technical reports and 1 individual did not answer the question. [b]Note that 109 individuals did not use U.S. Government technical reports and 8 individuals did not answer the question. [c]Note that 423 individuals did not use U.S. Government technical reports and 22 individuals did not answer the question.

using their personal store of technical information and personal communications when searching for information and U.S. government technical reports. A further look at table 44 indicates that survey participants actively seek information outside of their organization as indicated by the percentage of respondents who asked colleagues outside of the organization when trying to find out about U.S. government technical reports.

The information sources used to find out about U.S. government technical reports were examined from the standpoint of educational preparation as either engineers or scientists (table 45). Both engineers and scientists place a high value on

Table 45. Sources Used by Engineers and Scientists to Find Out About the U.S. Government Technical Reports Used to Complete Most Important Technical Project, Task, or Problem

Engineers (n = 993)[a]			Scientists (n = 155)[b]		
Source	n	Percentage who used	Source	n	Percentage who used
Used personal store of technical information	833	83.9	Used personal store of technical information	155	83.2
Intentionally searched library resources	492	49.5	Asked a colleague in my organization	85	54.8
Asked a colleague in my organization	579	58.3	Searched data base or had a data base searched	79	51.0
Asked a colleague outside my organization	490	49.3	Intentionally searched library resources	77	49.7
Searched data base or had a data base searched	436	43.9	Asked a colleague outside of my organization	77	49.7
Asked a librarian	303	30.5	By accident, browsing, or looking for other material	51	32.9
By accident, browsing, or looking for other material	252	25.4	Asked a librarian	43	27.7
Someone informed me without my asking	241	24.3	Someone informed me without my asking	32	20.6
Asked my supervisor	245	24.7	Asked my supervisor	21	13.5

[a]Note that 603 individuals did not use U.S. Government technical reports and 31 individuals did not answer the question. [b]Note that 77 individuals did not use U.S. Government technical reports and 3 individuals did not answer the question.

the technical information stored around them and on informal communications. Aside from these similarities there are some interesting differences. For both groups, asking their supervisor is the least used method of looking for U.S government technical reports. Engineers make much greater use of "intentionally searching library resources"

for U.S. government technical reports than do scientists. The percentages of "asked a colleague outside of the organization" to find out about U.S. government technical reports are fairly high for both groups. Both engineers and scientists have relatively low rates for using librarians and searching data bases to find out about U.S. government technical reports.

The information sources used to find out about U.S. government technical reports were examined from the standpoint of professional duties as either managers or nonmanagers (table 46). Using their personal store of technical information and discussions with colleagues are common to both managers and nonmanagers. Managers make greater use of colleagues "outside" of the organization and "by accident, browsing..." for finding out about U.S. government technical reports than did nonmanagers. On the other hand, nonmanagers make greater use of "intentionally searched library resources" and "asked my supervisor" than do managers for finding out about the U.S. government technical reports used to complete their most important technical project, task, or problem.

Overall, U.S. government technical reports are used throughout the entire process of completing the project or task or solving the problem about 67 percent of the time, near the beginning about 42 percent of the time, near the middle about 23 percent of the time, and near the end about 14 percent of the time (table 47).

Table 46. Sources Used by Managers and Nonmanagers to Find Out About the U.S. Government Technical Reports Used to Complete Most Important Technical Project, Task, or Problem

Managers (n = 774)			Nonmanagers (n = 1100)		
Source	n	Percentage who used	Source	n	Percentage who used
Used personal store of technical information	390	83.7	Used personal store of technical information	582	82.9
Asked a colleague in my organization	295	63.3	Intentionally searched library resources	382	54.4
Asked a colleague outside of my organization	261	56.0	Asked a colleague in my organization	380	54.1
Searched data base or had a data base searched	225	48.3	Asked a colleague outside of my organization	316	45.0
Intentionally searched library resources	199	42.7	Searched data base or had a data base searched	301	42.9
By accident, browsing, or looking for other material	206	29.3	Asked a librarian	219	31.2
			Asked by supervisor	176	25.1
Asked a librarian	131	28.1	Someone informed me without my asking	156	22.2
Someone informed me without my asking	122	26.2			
			By accident, browsing, or looking for other material	98	21.0
Asked my supervisor	87	18.7			

[a]Note that 203 individuals did not use U.S. Government technical reports and 31 individuals did not answer the question. [b]Note that 387 individuals did not use U.S. Government technical reports and 65 individuals did not answer the question.

Table 47. Stage U.S. Government Technical Reports Used in Completing Most Important Technical Project, Task, or Problem

Stage of work	Number (percentage) respondents in -			Total[a] respondents (n = 1144)
	Academia (n = 206)	Government (n = 337)	Industry (n = 601)	
Near beginning	95 (46.1)	130 (38.6)	260 (43.3)	485 (42.4)
Near middle	55 (26.7)	71 (21.1)	131 (21.8)	257 (22.5)
Near end	34 (16.5)	61 (18.1)	70 (11.6)	165 (14.4)
Throughout entire project, task, or problem	135 (65.5)	257 (76.3)	378 (62.9)	770 (67.3)

[a]Note that 666 individuals did not use U.S. Government technical reports and 29 did not answer the question but should have.

Survey participants rated the effectiveness of the U.S. government technical reports they used in completing their most important technical project or task or in solving their most important technical problem (table 48). Overall, U.S. government technical reports receive a 3.61 mean effectiveness rating. Statistically, government-affiliated participants rate U.S. government technical reports more effective ($\bar{X}$=3.77) than do academially ($\bar{X}$=3.61) and industry-affiliated respondents ($\bar{X}$=3.52).

Survey participants were also asked to indicate the efficiency of the U.S. government technical reports they used in completing their most important technical project or task or in solving their most important technical problem (table 49). Overall, U.S. government technical reports receive a 3.41 mean efficiency rating. Industry-affiliated participants rate U.S. government technical reports less effective ($\bar{X}$=3.30) than do their counterparts in academia ($\bar{X}$=3.45) and government ($\bar{X}$=3.58). Overall, U.S. government technical reports are considered by respondents to be more effective ($\bar{X}$=3.61) than efficient ($\bar{X}$=3.41) in completing their most important technical project or task or in solving their most important technical problem.

Table 48. Effectiveness of U.S. Government Technical Reports Used in Completing Most Important Technical Project, Task, or Problem

[Total respondents, 1162[a]]

Source	Average[b] (mean) effectiveness rating in -
Academia	3.62
Industry	3.52
Government	3.77
Overall	3.61

[a]Note that 666 individuals did not answer the question. [b]A 1 to 5 point scale was used to measure effectiveness, with "1" being the lowest possible effectiveness and "5" being the highest possible effectiveness. Hence, the higher the average (mean), the greater the effectiveness.

Table 49. Efficiency of U.S. Government Technical Reports Used in Completing Most Important Technical Project, Task or Problem

[Total respondents, 1157[a]]

Source	Average[b] (mean) efficiency rating in -
Academia	3.45
Industry	3.30
Government	3.58
Overall	3.41

[a]Note that 666 individuals did not answer the question. [b]A 1 to 5 point scale was used to measure efficiency, with "1" being the lowest possible efficiency and "5" being the highest possible efficiency. Hence, the higher the average (mean), the greater the efficiency.

DISCUSSION OF THE DATA

U.S. government technical reports are used and are important to the U.S. aerospace engineers and scientists who participated in this study. Predictably, conference-meeting papers and journal articles obtain a higher importance rating from academically affiliated respondents. In-house and U.S. government technical reports obtain a higher importance rating from government- and industry-affiliated respondents. Academically affiliated respondents also make greater use of conference-meeting papers and journal articles. Government- and industry-affiliated respondents make greater use of in-house and U.S. government technical reports.

Theory holds that accessibility, not technical quality, exerts greater influence on the use of information products and services by engineers. In this study, relevance has the greatest influence on the use of conference-meeting papers, journal articles, in-house technical reports, and U.S. government technical reports. In terms of organizational affiliation, technical quality or reliability has the greatest influence on the use of journals articles. If theory holds true, it appears not to apply to those U.S. aerospace engineers and scientists who participated in this study.

With one minor exception the four information products (conference-meeting papers, journal articles, in-house technical reports, and U.S. government technical reports) are used most often for research and education. Basic scientific and technological information and in-house technical data are used most often by survey participants. Most in-house technical data, computer programs, technical specifications, and product and performance characteristics are obtained from in-house and U.S. government technical reports.

The most important project, task, or problem undertaken in the past 6 months were either research, development, or design in nature. About 65 percent of the survey respondents use U.S. government technical reports in completing their most important project or task or solving their most important problem. About two-thirds of these reports are used throughout the completion of the project, task, or problem. U.S. government technical reports are considered to be more efficient than effective by survey respondents who use them in terms of completing their most important project, task, or problem.

The U.S. aerospace engineers and scientists in this study place high value on the information stored around them and on informal communications. This characteristic conforms to the information-seeking behavior reported for engineers in other disciplines. Further, their approach to completing technical project or tasks or to problem solving involves personal contact with a variety of people. It is not until they have exhausted their personal store of technical information and have consulted various individuals that U.S. aerospace engineers and scientists turn to formal information sources such as librarians and data bases. This finding is in keeping with previous engineering information use studies. It appears that the participants in this study rarely find all the information they need in one source. Also, they appear to approach the formal system only after having discussed their project, task, or problem with colleagues. This pattern or approach to information-seeking also applies to how survey respondents go about finding out about the U.S. government technical reports they use in performing their present professional duties.

CHAPTER 6

TEST OF THE HYPOTHESES

INTRODUCTION

This chapter, which contains the test of the hypotheses, contributes to the immediate and broader purposes of the study. In the first instance, the U.S. government technical report is placed within the context of factors assumed to influence its use. In the second instance, the information-seeking habits and practices of U.S. aerospace engineers and scientists are viewed in terms of selected institutional and sociometric variables assumed to influence the use of four information products.

BACKGROUND

The following question expresses the problem statement for *this* study. Which variables explain the use of U.S. government technical reports by U.S. aerospace engineers and scientists? Two sets of variables were investigated. The first set, identified as institutional or structural variables, includes the following six variables: level of education, academic preparation, years of professional aerospace work experience, type of organization, professional duty, and technical discipline. The second set, identified as sociometric or source selection variables, includes the following seven variables: accessibility, ease of use, expense, familiarity or experience, technical quality or reliability, comprehensiveness, and relevance.

The goal of *this* study is to provide an empirical basis for understanding the role of the U.S. government technical report in the diffusion of knowledge resulting from federally funded aerospace R&D. The study assumes that the U.S. government technical report plays an important, but as yet undefined, role in the aerospace knowledge diffusion process. The following three research questions are based on this assumption. First, do the six institutional or structural variables explain the use of U.S. government technical reports by U.S. aerospace engineers and scientists? Second, do the seven sociometric or source selection variables explain the use of U.S. government technical reports by U.S. aerospace engineers and scientists? Third, when both the institutional and sociometric variables are considered, does one set of variables predominate in terms of explaining use?

PRESENTATION OF THE FINDINGS

The eight hypotheses formulated for *this* study are based on the three research questions. The hypotheses are based on "an assumed relationship" and, therefore, are stated as alternative hypotheses. Each hypothesis was tested at the $p < 0.05$ level of statistical significance. The chi square test of independence was the statistic used to test hypotheses 1 to 6, identified herein as the institutional or structural variables. The Pearson product-moment correlation, or the Pearson coefficient, was the statistic used to test hypothesis 7, identified herein as the sociometric or source selection variables. No statistic was used to test hypothesis 8.

Institutional or Structural Variables

Hypothesis 1: The absence or presence of a graduate degree significantly influences the use of U.S. government technical reports by U.S. aerospace engineers and scientists.

Hypothesis 1 was tested by cross-tabulating Q3G, "number of times U.S. government technical reports used in the past 6 months," by Q56, "highest level of education or highest educational degree." The chi square computer analysis follows.

Q3G Use of U.S. government technical reports in the past 6 months
Q56 Highest level of education or degree

Q3G (Count / Col Pct)	Q56-> NO GRD.EDUC	GRAD EDUC	Row Total
0-3	203 46.7	476 41.6	679 43.0
4-6	97 22.3	276 24.1	373 23.6
7-12	68 15.6	196 17.1	264 16.7
13-500	67 15.4	196 17.1	263 16.7
Column Total	435 27.5	1144 72.5	1579 100.0

Chi-Square	D.F.	Significance	Min E.F.	Cells with E.F.< 5
3.31175	3	.3460	72.454	None

Number of Missing Observations = 437

It was hypothesized that level of education, operationally defined as having either a bachelor's degree or less or a graduate degree, and the use of U.S. government technical reports by U.S. aerospace engineers and scientists are dependent. This assumption of a relationship is based on the belief that the process

of academic socialization or enculturation involved in obtaining a master's degree or a Ph.D. influences the use and production of information. The chi square test of independence, however, revealed that the two variables are independent, that is, the use of U.S. government technical reports is not related to or dependent on level of education. Therefore, the alternative hypothesis is rejected and the null hypothesis of "no relationship" is accepted.

Hypothesis $_1$: Academic preparation as either an engineer or scientist significantly influences the use of U.S. government technical reports by U.S. aerospace engineers and scientists.

Hypothesis 2 was tested by cross-tabulating Q3G, "number of times U.S. government technical reports used in the past 6 months," by Q57A, "educational preparation." The chi square computer analysis follows.

Q3G Use of U.S. government technical reports in the past 6 months
Q57A *Educational preparation* as either an engineer or scientist

Q3G / Q57A-> (Count, Col Pct)	ENGINEER	SCIENCE	Row Total
0-3	584 44.2	68 35.8	652 43.2
4-6	309 23.4	44 23.2	353 23.4
7-12	218 16.5	32 16.8	250 16.6
13-500	209 15.8	46 24.2	255 16.9
Column Total	1320 87.4	190 12.6	1510 100.0

Chi-Square	D.F.	Significance	Min E.F.	Cells with E.F.< 5
9.66586	3	.0216	31.457	None

Number of Missing Observations = 506

It was hypothesized that academic preparation, operationally defined as being either an engineer or a scientist, influences the use of U.S. government technical reports by U.S. aerospace engineers and scientists. The assumption of a relationship is based on the belief that the technical report is the information product preferred by engineers and the journal article is the information product favored by scientists. The chi square test of independence revealed that the use of U.S. government technical reports is related to academic preparation. Therefore, the alternative hypothesis of "a relationship" is accepted. However, the data do reveal that scientists use U.S. government technical reports more than engineers.

This hypothesis was further explored with a slight variation. Present professional duties (Q57B) as either an engineer or a scientist was substituted for academic preparation (Q57A) as either an engineer or a scientist. The chi square test of independence, however, revealed that the two variables are independent, that is, the use of U.S. government technical reports is not related to or dependent on present professional duties as either an engineer or a scientist. Therefore, the alternative hypothesis is rejected and the null hypothesis of "no relationship" is accepted.

Hypothesis $_1$: Years of professional aerospace work experience as 15 years or less or 16 years or more significantly influences the use of U.S. government technical reports by U.S. aerospace engineers and scientists.

Hypothesis 3 was tested by cross-tabulating Q3G, "number of times U.S. government technical reports used in the past 6 months," by Q58, "years of professional aerospace work experience." The chi square computer analysis follows.

Q3G Use of U.S. government technical reports in the past 6 months
Q58 Years of professional aerospace work experience

Q3G \ Q58-> (Count / Col Pct)	10-15 YEARS	16 OR MORE	Row Total
0-3	281 48.5	393 39.7	674 43.0
4-6	130 22.5	242 24.4	372 23.7
7-12	78 13.5	184 18.6	262 16.7
13-500	90 15.5	171 17.3	261 16.6
Column Total	579 36.9	990 63.1	1569 100.0

Chi-Square	D.F.	Significance	Min E.F.	Cells with E.F.< 5
13.62874	3	.0035	96.315	None

Number of Missing Observations = 447

The assumption of a relationship is based on the belief that use and production of information peaks and declines at some point in a researcher's career. The chi square test of independence revealed that the use of U.S. government technical reports is related to years of professional aerospace work experience. Therefore, the alternative hypothesis of "a relationship" is accepted. However, the data do reveal that those participants with 16+ years of experience use U.S government technical reports more.

Hypothesis $_1$: Organizational affiliation as either academic, government, or industry significantly influences the use of U.S. government technical reports by U.S. aerospace engineers and scientists.

Hypothesis 4 was tested by cross-tabulating Q3G, "number of times U.S. government technical reports used in the past 6 months," by Q59, "type of organization where you work." The chi square computer analysis follows.

Q3G Use of U.S. government technical reports in the past 6 months
Q59 Type of organization where you work

Q3G \ Q59-> Count / Col Pct	ACADEMIC	GOVRMNT	INDUSTRY	Row Total
0-3	119 43.4	154 40.5	369 43.9	642 42.9
4-6	67 24.5	98 25.8	192 22.8	357 23.9
7-12	48 17.5	56 14.7	147 17.5	251 16.8
13-500	40 14.6	72 18.9	133 15.8	245 16.4
Column Total	274 18.3	380 25.4	841 56.3	1495 100.0

Chi-Square	D.F.	Significance	Min E.F.	Cells with E.F.< 5
5.21035	6	.5171	44.903	None

Number of Missing Observations = 521

The assumption of a relationship is based on the belief that organizational affiliation influences the use and production of information. The chi square test of independence, however, revealed that the two variables are independent, that is, the use of U.S. government technical reports is not related to organizational affiliation. Therefore, the alternative hypothesis is rejected and the null hypothesis of "no relationship" is accepted.

Hypothesis 5: Management and nonmanagement professional duties significantly influence the use of U.S. government technical reports by U.S. aerospace engineers and scientists.

Hypothesis 5 was tested by cross-tabulating Q3G, "number of times U.S. government technical reports used in the past 6 months," by Q60, "type of duty as either management or nonmanagement." The chi square computer analysis follows.

Q3G Use of U.S. government technical reports in the past 6 months
Q60 Type of duty as either management or nonmanagement

Q3G (Count / Col Pct) \ Q60->	NON-MGMT	MGMT	Row Total
0-3	376 42.3	278 43.8	654 42.9
4-6	212 23.9	148 23.3	360 23.6
7-12	160 18.0	97 15.3	257 16.9
13-500	140 15.8	112 17.6	252 16.5
Column Total	888 58.3	635 41.7	1523 100.0

Chi-Square	D.F.	Significance	Min E.F.	Cells with E.F.< 5
2.66273	3	.4466	105.069	None

Number of Missing Observations = 493

The assumption of a relationship is based on the belief that use of information products is influenced by the performance of either management or nonmanagement duties. The chi square test of independence, however, revealed that the two variables are independent, that is, the use of U.S. government technical reports is not related to or dependent on management or nonmanagement

professional duties. Therefore, the alternative hypothesis is rejected and the null hypothesis of "no relationship" is accepted.

Hypothesis $_1$: Engineering and science technical disciplines significantly influence the use of U.S. government technical reports by U.S. aerospace engineers and scientists.

Hypothesis 6 was tested by cross-tabulating Q3G, "number of times U.S. government technical reports used in the past 6 months," by Q62, "technical discipline." The chi square computer analysis follows.

Q3G Use of U.S. government technical reports in the past 6 months
Q62 Technical discipline as either engineering or science

Q3G / Q62->	Count / Col Pct	ENGINEER	SCIENCE	Row Total
0-3		549 44.5	140 38.4	689 43.1
4-6		287 23.3	88 24.1	375 23.5
7-12		212 17.2	55 15.1	267 16.7
13-500		185 15.0	82 22.5	267 16.7
	Column Total	1233 77.2	365 22.8	1598 100.0

Chi-Square	D.F.	Significance	Min E.F.	Cells with E.F.< 5
12.71546	3	.0053	60.986	None

Number of Missing Observations = 418

The assumption of a relationship is based on the belief that the use of information products is influenced by a researcher's technical discipline. Accordingly, researchers working in engineering disciplines (Q62; 1-3) would favor technical reports and those

working in science disciplines (Q62; 4-9) would prefer journal articles. The chi square test of independence revealed that the use of U.S. government technical reports is related to a researcher's technical discipline. Therefore, the alternative hypothesis of "a relationship" is accepted. However, the data do reveal that survey participants working in science disciplines use them more.

Sociometric or Source Selection Variables

> Hypothesis $_1$: Accessibility, as opposed to the six remaining sociometric or source selection variables, significantly influences the use of U.S. government technical reports by U.S. aerospace engineers and scientists.

Hypothesis **7** was tested by correlating Q3G, "number of times U.S. government technical reports used in the past 6 months," by Q25-Q31, "to what extent was the use of U.S. government technical reports influenced by the following factors." It was hypothesized that accessibility exerts the greatest influence on use. However, after analyzing the correlation coefficients produced, there were no significant correlations between use of U. S. government technical reports and **any** of the seven sociometric or source selection variables.

To further explore this hypothesis, the correlation coefficient statistic was also used to test the use of conference-meeting papers, journal articles, and in-house technical reports. A significant correlation coefficient (r=0.06) exists for journal articles and accessibility. A significant correlation coefficient also exists for journal articles and expense (r=0.068), familiarity (r=0.07), technical quality (r=0.102), comprehensiveness (r=0.087), and reliability (r=0.112). Significant correlation coefficients also exist between

in-house technical reports (r=0.083) and conference-meeting papers (r=0.096) and reliability. Considering the correlation coefficients, the alternative hypothesis is rejected and the null hypothesis of "no relationship" is accepted. That is, the use of U.S. government technical reports is independent of accessibility. Accessibility is not statistically different from any other sociometric variable and the use of U.S. government technical reports.

Institutional or Structural and Sociometric or Source Selection Variables

> Hypothesis $_1$: The institutional or structural variables, as opposed to the sociometric or source selection variables, significantly influence the use of U.S. government technical reports by U.S. aerospace engineers and scientists.

No formal statistic was needed to test hypothesis **8**. The acceptance or rejection of this hypothesis is based on a subjective assessment of the available data. The use of U. S. government technical reports is **not independent** of three of the six institutional or structural variables. The use of U.S. government technical reports **is independent** of all seven sociometric or source selection variables. Based on these data, it is concluded that a relationship exists between use and the institutional or structural variables. Therefore, the alternative hypothesis of "a relationship" is accepted. That is, taken as a group, use of U.S. government technical reports by U.S. aerospace engineers and scientists is not independent of the institutional or structural variables. However, the use of U.S. government technical reports by U.S. aerospace engineers and scientists is independent of the seven sociometric or source selection variables.

DISCUSSION OF THE FINDINGS

This study assumes that the U.S. government technical report plays an important, but as yet undefined, role in the aerospace knowledge diffusion process. The following three research questions are based on this assumption.

First, do the six institutional or structural variables explain the use of U.S. government technical reports by U.S. aerospace engineers and scientists? The institutional or structural variables include the following six variables: level of education, academic preparation, years of professional work experience in aerospace, type of organization, professional duty, and technical discipline. These variables were tested using the chi square statistic to determine their relationship to the four information products included in *this* study. The results of these tests are summarized below.

	Level of education	Academic preparation	Years of work experience	Type of organization	Professional duties	Technical discipline
Conference-meeting papers	*	*		*	*	
Journal articles	*	*		*	*	*
In-house technical reports				*	*	
U.S. government technical reports		*	*			*

*Significant χ^2 value at $p < 0.05$.

The 4 information products and the 6 institutional or structural variables create a 24-cell matrix. The results of the chi square tests indicate that 58-percent

of the cells in the matrix show a dependent relationship. The results of the chi square tests indicate that 83.3-percent of the cells in the matrix show a dependent relationship for the six variables and the use of journal articles, followed by conference-meeting papers (66.6 percent), U.S. government technical reports (50.0 percent), and in-house technical reports (33.3 percent).

However, no one variable predominates. A dependent relationship exists between three variables (academic preparation as either an engineer or a scientist, type of organization as either academic, government, or industry, and professional duties as either management or nonmanagement) and use of conference-meeting papers, journal articles, and U.S. government technical reports.

A dependent relationship exists between level of education (as either the absence or presence of a graduate degree) and technical discipline (as either an engineering or a science discipline) and use of conference-meeting papers and journal articles. A dependent relationship exists between years of professional aerospace work experience and use of U.S. government technical reports. However, to answer the first research question posed for the study, the use of U.S. government technical reports by U.S aerospace engineers and scientists is **not independent** of academic preparation as either an engineer or scientist, years of professional aerospace work experience as 15 years or less and 16 years or more, and technical discipline as either engineering or science.

Second, do the seven sociometric or source selection variables explain the use of U.S. government technical reports by U.S. aerospace engineers and scientists? The chi square test of independence, a weaker statistic in this application, was used

to test for relationships between the number of conference-meeting papers (Q3C), journal articles (Q3J), and in-house technical reports (Q3I) used in a 6-month period and Q4-Q10, Q11-17, and Q18-24, respectively, "to what extent was their use influenced by the following factors." The results of these tests are summarized below.

	Accessibility	Ease of use	Expense	Familiarity or experience	Technical quality or reliability	Comprehen-siveness	Relevance
Conference-meeting papers	*	*		*	*		*
Journal articles	*	*	*	*	*	*	*
In-house technical reports	*	*	*	*	*	*	*
U.S. government technical reports	*	*	*	*	*	*	*

*Significant χ^2 value at $p < 0.05$.

The 4 information products and the 7 sociometric or source selection variables create a 28-cell matrix. The results of the chi square tests indicate that a 93-percent of the cells in the matrix show a dependent relationship. The test results indicate a dependent relationship between use of conference-meeting papers and five of the seven variables. The test results also indicate a dependent relationship between the use of journal articles, in-house technical reports, and U.S. government technical reports and all seven of the source selection variables. However, to answer the second research question posed for the study, the use of U.S. govern-

ment technical reports by U.S. aerospace engineers and scientists is independent of all seven sociometric or source selection variables. A weak argument can be made for a relationship between relevance, technical quality or reliability, and comprehensiveness based on the correlation coefficients recorded for the other three information products and the overall mean importance ratings assigned by respondents to "use influenced by." However, a different research design is needed before the question can be successfully answered.

Third, when both the institutional and sociometric variables are considered, does one set of variables predominate in terms of explaining use? Based on the available data, it appears that the institutional, not the sociometric, variables best explain the use of U.S. government technical reports. However, a different research design is needed before the question can be successfully answered.

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER RESEARCH

INTRODUCTION

This chapter contributes to the immediate and broader purposes of the study. First, background regarding Federal involvement in technological innovation and knowledge diffusion is presented. Second, a discussion of findings about the role of the U.S. government technical report in the diffusion of knowledge resulting from federally funded aerospace R&D and the information-seeking habits and practices of U.S. aerospace engineers and scientists is offered. Finally, the chapter concludes with some thoughts for further research.

BACKGROUND

The role of the Federal government in stimulating technological innovation remains the subject of serious debate. Proponents of the free enterprise system persistently point out the deleterious effects of regulation and control on innovation. Supporters of this view take the position that U.S. government involvement in technological innovation is virtually always expensive folly. Nelson (1982) believes many attempts by the Federal government to stimulate increased commercialization of technology were just that. Conversely, those advocating a more "active" government role cite economic vulnerability, lagging productivity, unfavorable trade balances, losses of

traditional markets, and unemployment as primary reasons for government intervention (Chakrabarti and Souder, 1984). Supporters of this position view increased technological innovation as a general solution to national conditions and argue that such programs are designed to **supplement**, not **supplant**, the marketplace.

While Federal involvement invokes considerable discussion and debate, there is general consensus that current conceptual and empirical knowledge regarding both the process of technological innovation and U.S. government intervention is lacking. According to Curlee and Goel (1989), recognition is growing that technology transfer and diffusion is the "key" to the success of technological innovation. Although consider-able research into technological innovation and knowledge diffusion has been conduct-ed by various disciplines and from numerous perspectives, policy implications from the results of this research and investigation are inconsistent and often contradictory. Tornatzky and Fleischer (1990) find that the "United States has no coherent innovation or technology policy." The United States does, however, have "many programs and numerous policies which cut across political jurisdictions and the idiosyncratic missions and mandates of single agencies which are more or less responsive to a series of shifting political alliances and imperatives" (Tornatzky and Fleischer, 1990).

Beginning in the 1960s, Federal attempts at stimulating and nurturing technological innovation represented a dramatic departure from earlier policy positions based on a strict interpretation of the "general welfare" clause of the U.S. Constitution (Rosenberg, 1985). Heretofore, the Federal government had limited itself to activities either directly or explicitly tied to an existing responsibility of a specific government

agency. In the early 1970s, government took an increasingly active role in stimulating technological change and innovation in the civilian economy (Baer, et al., 1977).

These new initiatives were justified, in large part, by the economic concept of **externalities** (Eads, 1974). Central to understanding the theoretical framework for this concept is the work of Nelson (1959) and Arrow (1962). Eads finds that a concise statement of the basic theory of externalities and its policy implications for Federal involvement and investment in technological innovation is found in the 1972 Economic Report of the President's Council of Economic Advisors:

> Government has an appropriate role in R&D even when its results will not be incorporated in Government purchases, because private firms would underinvest in R&D for goods normally purchased by the *private* sector. Although an investment in R&D may produce benefits exceeding its costs from the viewpoint of society as a whole, a firm considering the investment may not be able to translate enough of these benefits into profits on its own products to justify the investment. This is because the knowledge which is the main product of R&D can usually be readily acquired by others who will compete away at least part of the benefits from the original developer. This is particularly true of basic research, where the output frequently occurs in the first instance not as a marketable product, but rather as an advance in basic knowledge that can subsequently be used in applied research and development by a wide and often unforeseeable range of firms.

According to Mowery (1983), Nelson (1959) and Arrow (1962) argue that the social returns to research investment exceed the private returns faced by the individual firm, leading to underinvestment by the firm, from the societal point of view, in research. Arrow argues that while the firm's costs of investment in knowledge production are substantial, the costs of transferring the new knowledge are effectively zero. From a social point of view, the widest possible diffusion of knowledge is optimal. However, the price necessary to achieve this end, that is, one equal to the costs of transfer, is so low as to bankrupt the discoverer. Thus, the supply of socially

beneficial research in civilian technologies is insufficient, due to a disjunction between the privately and socially optimal prices for the results. Mowery (1983) further states that these analyses of market failure justify Federal subsidies to civilian basic research and that these same arguments were later extended to civilian applied research.

According to the concept of externalities, the decentralized private market mechanism will not generate the level and kind of technological innovation that maximizes the welfare of society. Market failure can arise from three sources (Baer, et al., 1977). First, the benefits to society from a firm's R&D activities may exceed the benefits that the firm can capture as profits. Unpredictable research results are hard for an originating firm to capture. The cost of producing new knowledge through research is high, but the cost of reproducing it is low. Patents and copyrights only partially alleviate the disparity, leading firms to invest less in R&D activities than is socially optimal. Second, the production of some goods and services gives rise to externalities, positive and negative, that are not reflected in the prices of the goods, services, or inputs into production. Third, private markets may operate inefficiently because of high information or transaction costs, or distortions caused by government.

As Eads (1974) points out, Federal support for civilian technology was designed to correct market failure so that the market then could be relied upon to provide correct signals for private investment in technological change. Eads goes further with a cautionary note that "the economic history of the U.S. is full of attempts by the government to correct through direct intervention what have been perceived by some as failures of markets to direct economic activity properly. However, in an unfortunately large number of cases, these attempts have been unsuccessful. The market

failures, either real or imagined, have not been corrected, and, what is worse, a host of new market distortions have been created."

Consequently, understanding the influences that motivate innovation and channel its direction is necessary for government intervention to successfully increase the production of useful innovation. Nelson (1983) and Pavitt and Walker (1976) review and analyze government policies and programs toward technological innovation. Federal innovation policy and prescription, they state, encourage innovation, not its adoption; knowledge transfer and utilization [diffusion] are "very inadequately served by market forces and the incentives of the market place." They conclude government would better serve public policy by assuming a more active role in the knowledge diffusion process and formulating policies and programs that encourage and improve communications between users and producers of knowledge.

David (1986), Mowery (1983), and Mowery and Rosenberg (1979) conclude that successful [Federal] technological innovation rests more with the transfer and utilization of knowledge than with its production. In a critique of Federal innovation policy, David states that "innovation has become our cherished child, doted upon by all concerned with maintaining competitiveness and renewing failing industries; whereas diffusion has fallen into the woeful role of Cinderella, a drudge-like creator who tends to be overlooked when the summons arrived to attend the Technology Policy Ball."

Utilizing existing scientific and technical information (STI) and/or creating new STI often facilitates technological innovation. Testimony to the central role of STI in the innovation process is found in numerous studies. Many studies show strong relationships between the communication of STI and technical performance at both the

individual (Allen, 1970) and group levels (Smith, 1970). The role of STI is central to the innovation process and to its management (Fischer, 1980). Therefore, STI is essential to technological innovation, but STI by itself does not ensure technological innovation. Thus, understanding how STI is communicated in the process of technological innovation is critical for assessing the broad set of Federal policies that influence the production, transfer, and utilization of STI (Ballard, et al., 1989).

Stimulating and nurturing technological innovation to enhance U.S. economic competitiveness requires understanding how STI is produced, transferred, and utilized. Numerous panels and commissions have attempted to determine the proper role of the Federal government in promoting the production, transfer, and utilization of STI.

Three approaches or models have dominated attempts to facilitate the transfer and utilization of federally funded STI (Ballard, et al., 1989). The appropriability model, based on neoclassical economics, is built on a "supply-side" approach that emphasizes the production of STI by the Federal government, not its transfer and utilization. The appropriability model dominates many aspects of Federal STI policy.

The dissemination model emphasizes the need to transfer the results of federally funded STI to non-Federal users. This model, based on the assumption that production of STI will not ensure its use, emerged in response to concern that federally-produced STI was not used to its fullest potential. This model, characterized by the large-scale STI programs operated by the DOD, DOE, and NASA, emphasizes accessibility. These agencies maintain STI systems for acquiring, processing, announcing, and disseminating the results of government-performed and government-sponsored research. Within these systems, the U.S. government technical report is used as a primary means of trans-

ferring the results of federally funded R&D. Bikson, et al., (1984) have characterized these systems as "passive, fragmented, and nonresponsive to the user context."

The knowledge utilization model assumes an active approach to linking producers and users of STI and seeks to remove two barriers to the effective transfer of STI: inadequate interpersonal communication between producers and users throughout the production, transfer, and utilization process, and organizational barriers. According to Ballard, et al., (1989), rather than basing the system on production and supply of STI (the appropriability model) or focusing on products and services that make STI more accessible (the dissemination model), the knowledge utilization model emphasizes the relationships among all components of the production, transfer, and use process. The assumption is that the results of federally funded R&D will be underutilized unless they are relevant to the needs of the users and ongoing relationships are developed among producers and users. The problems associated with this model are twofold -- (1) the lack of clear understanding of the information-seeking behavior of engineers and scientists involved in technological innovation and (2) the lack of attention to characterizing the implications of information-seeking behavior in terms of Federal innovation and STI policy.

The Federal government should play a role in stimulating and nurturing technological innovation; however, no consensus exists regarding the exact role government should play. Lack of consensus stems from differing political philosophies concerning the proper role of government, a general lack of understanding about technological innovation, and the fragmented nature of Federal innovation policy.

There is widespread agreement that federally funded STI is vital to successful technological innovation. However, many Federal activities in information policy have little relevance to the use of STI for technological innovation because, according to Ballard, et al., (1989), "they are based on a passive philosophical perspective that holds that free and open information will eventually be used for technological and economic benefit." Information policy debates, until recently, have generally not been linked to technological innovation. Instead they have focused on privatizing Federal agencies and data bases, determining appropriate rate charges for government information, and denying access to STI for reasons of national security.

While important, such debates distract from the larger issue of how to improve the efficiency and effectiveness of the innovation process through the use of federally funded STI. Successful technological innovation requires a broader view that encompasses Federal science and technology policy, information policy, tax policy, and economic policy. Hernon and McClure (1987) and McClure and Hernon (1989) provide useful background on Federal information and STI policy. Technological innovation also requires an understanding of knowledge diffusion both in terms of the channels used to communicate ideas and the information-seeking habits and practices of engineers and scientists involved in the process of technological innovation.

CONCLUSIONS FROM THIS STUDY

Conclusions are presented within the context of technological innovation and knowledge diffusion and are subject to the limitations established for the study.

The U.S. Government Technical Report

The U.S. government technical report constitutes an important information product in the diffusion of knowledge resulting from federally funded aerospace R&D. These reports are used for research, education, and management purposes, in problem solving, and in completing projects and tasks. Relevance, technical quality, and accessibility are the factors that influence their use by survey participants. A relationship exists between use of U.S. government technical reports and academic preparation, years of work experience, and technical discipline.

Ballard's (1989) statement that U.S. government technical reports are not used for reasons of technical quality and reliability appears not to hold true for the U.S. aerospace engineers and scientists who participated in this study. Further, McClure's (1988) concerns that these reports may be the most ignored and inaccessible STI products in the world may not hold true for survey participants. However, much more research is needed before a more conclusive statement can be made regarding the role of the U.S. government technical report in the aerospace knowledge diffusion process.

The Information-Seeking Behavior of U.S. Aerospace Engineers and Scientists

The U.S. aerospace engineers in this study prefer informal sources of information, especially conversations with individuals **within** their organization, when solving technical problems. Engineers solve problems and may have psychological traits that predispose them to solve problems alone or with the help of colleagues rather than to seek answers in the literature. They draw on past experiences and consult reliable and efficient colleagues instead of having someone search the literature for them. The U.S. aerospace engineers and scientists who participated in this study match that profile.

The engineer's search for information seems to be based more on a need for solving specific problems than around a search for general opportunity. Engineers use the library more in a personal-search mode, generally not involving the professional (but "nontechnical") librarian. When engineers need technical information, they use accessible sources: colleagues, vendors, and internal company [technical] reports. Engineers prefer informal over formal information systems. This characterization also describes the U.S. aerospace engineers and scientists who participated in this study. When completing a project or task or when solving a problem, they begin by using their personal stores of technical information followed by discussions with colleagues. They will then interact with the formal system by seeking the assistance of a librarian. This method also applies to their obtaining U.S. government technical reports.

RECOMMENDATIONS FOR FURTHER RESEARCH

1. Research directed at understanding the aerospace knowledge diffusion process is needed. This research should focus on the members of the social system and the channels used in communicating and transferring knowledge. Specific attention should be paid to the U.S. government technical report and librarians and technical information specialists as information intermediaries.

2. An understanding of the information-seeking behavior of U.S. aerospace engineers and scientists in aerospace technological innovation is directly related to the technological process. This research could be cross-cultural, involving aerospace engineers and scientists from several nations.

3. An analysis of existing Federal STI policies and practices should be undertaken. This analysis should be conducted within a general policy framework that focuses on Federal innovation, industry, and science and technology policy.

4. A systems analysis of the policies and practices used by NASA and DOD with respect to dissemination of federally funded R&D should be undertaken. This analysis should include an assessment of current theory and knowledge relative to technology transfer and knowledge diffusion. The goal should be to increase both the effectiveness and efficiency of the transfer process.

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APPENDIX A
DEFINITIONS OF TERMS

1.	Aerospace Engineers and Scientists	This is a generic term that includes those engineers and scientists who, regardless of their training, are involved in the theory, principles, design, development, testing, manufacture, and operation of aircraft, space vehicles, and related components and systems.
2.	Aerospace Industry	The aerospace industry in the United States includes aircraft; aircraft engines, parts, and equipment; guided missiles space vehicles; space propulsion units and parts; and space equipment.
3.	AIAA Special Interest Groups	These include aerospace science; aircraft systems; structures, design, and tests; propulsion and energy; aerospace and information systems; and administration or management.
4.	Applied Research	This is research directed toward gaining knowledge or understanding necessary for determining the means by which a recognized and specific need may be met.
5.	Basic Research	This is research primarily concerned with gaining a fuller understanding or knowledge of the subject under study rather than a practical application thereof.
6.	Descriptive Research	This is a type of research or research strategy that seeks to explore or describe what is happening or has happened; it involves the collection of data to answer questions concerning the current status of a subject or study. In the social sciences, descriptive data are usually collected through survey questionnaires, interviews, observations, or document analysis.
7.	Education	Education is categorized as not having a degree, a bachelor's degree, a master's degree, or a doctorate.
8.	Formal Sources	Sources of information best characterized as involving the use of books, journals, technical reports, data bases, and interaction with information professionals such as librarians and information specialists.

9.	Informal Sources	Sources of information best characterized as involving personal contact with a variety of individuals such as colleagues, supervisors, consultants, and vendors.
10.	Information Source Selection Criteria	Information source selection criteria include accessibility, expense, comprehensiveness, ease of use, familiarity or experience, relevance, and technical quality or reliability.
11.	Professional Duties	Professional duties include research, administration management, design development, manufacturing production, marketing sales, private consultant, service maintenance, and academic teaching.
12.	Research and Development	The systematic use of knowledge and understanding gained from research and directed toward the production of useful materials, devices, systems, or methods, including design and development of prototypes and processes.
13.	Research and Technology	The initial phase of research and development, which consists of activities primarily aimed at producing physical understanding; new concepts; design data; and validated design procedures for aircraft systems, subsystems, and components. It consists of activities ranging from theoretical analysis to laboratory investigations to flight-testing experiment aircraft.
14.	Special Library	A library with a special collection of materials that is usually limited by subject (for example, aeronautics) or form (for example, technical reports) in accordance with the interests of its users. These libraries operate in support of a special purpose or activity determined by the mission of the sponsoring organizations. Organizationally, these libraries may be found in academic settings, in large public libraries, in business and industry, in government, and in nonprofit organizations.
15.	STI	STI is defined as information used for or resulting from R&D activities and includes basic scientific data and technology information, computer programs, in-house technical data, technical specifications, and product and performance characteristics.

16.	Survey Research	A type of research or research strategy that attempts to collect data from members of a population by taking a sample from the population in order to determine the current status of that population with respect to one or more variables. The instrument most frequently associated with survey research is the survey questionnaire.
17.	Technical Discipline	Technical disciplines include aeronautics, astronautics, chemistry and materials, communications, computational fluid dynamics, engineering, fluid mechanics, geosciences, life sciences, math and computer science, physics, psychology, and space sciences.
18.	Type of Organization	Type of organization includes academic, government, industry, and nonprofit.
19.	U.S. Government Technical Reports	A subset of government documents that document the results of U.S. government-performed and government-sponsored research and development. These reports are published by the DOD and NASA; have a unique, issuer-supplied report number; may have a contract or grant number and an accession number; and, after initial distribution, may be obtained from a clearinghouse such as the National Technical Information Service, the Defense Technical Information Center, or the NASA Scientific and Technical Information Facility.

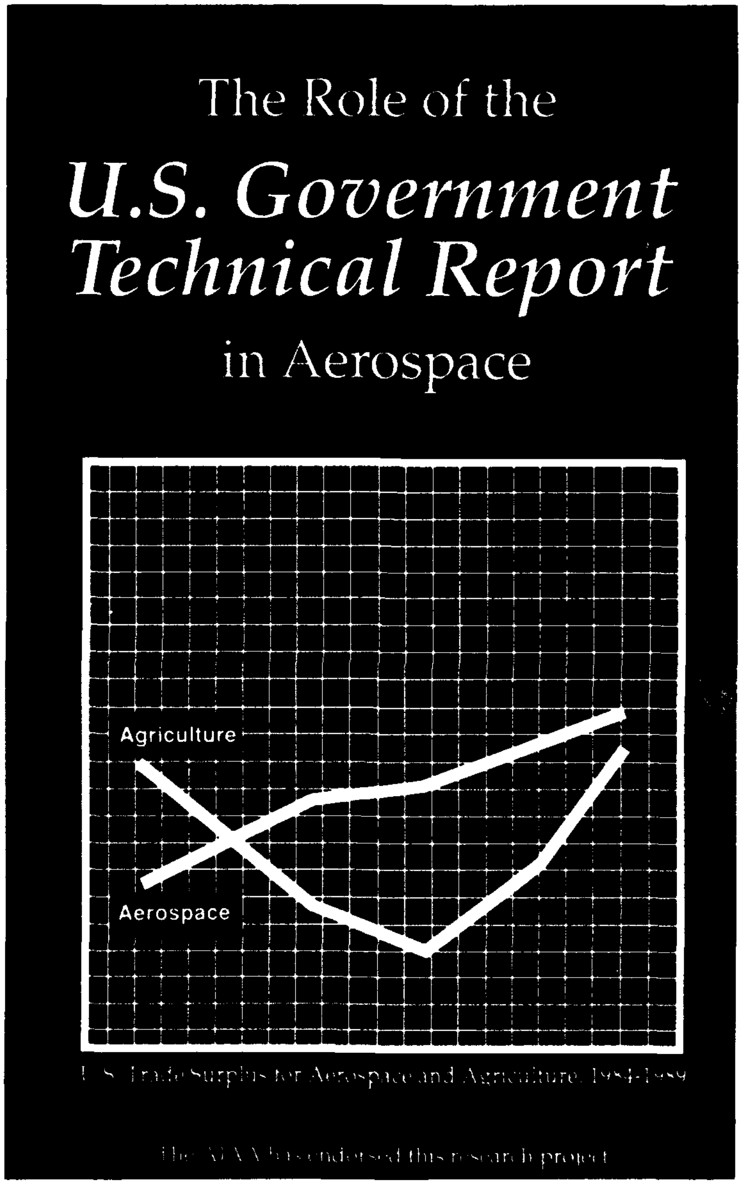
APPENDIX B
ACRONYMS

ADD	automatic document distribution
AIAA	American Institute of Aeronautics and Astronautics
AKA	also known as
ANOVA	analysis of variance
ARIST	Annual Review of Information Science and Technology
ASTIA	Armed Services Technical Information Agency, U.S. Department of Defense
AV	audiovisual
CAB	Civil Aeronautics Board; Current Awareness Bibliography
CARP	Cooperative Automotive Research Program
CENDI	Commerce, Energy, NASA, and Defense Information
CFSTI	Clearinghouse for Federal Scientific and Technical Information, U.S. Department of Commerce
COSATI	Committee on Scientific and Technical Information
DDC	Defense Documentation Center, U.S. Department of Defense
DOD	(U.S.) Department of Defense
DOE	(U.S.) Department of Energy
DROLS	Defense RDT&E On-Line System
DTIC	Defense Technical Information Center U.S. Department of Defense
EDB	energy data base
ERDA	Energy Research and Development Administration
ERIC	Educational Resources Information Center, U.S. Department of Education

GPO	(U.S.) Government Printing Office
GRA&I	Government Reports Announcements and Index
IU	Indiana University
LC	Library of Congress
LISA	Library and Information Science Abstracts
MIT	Massachusetts Institute of Technology
M.S.	Master of Science
NACA	National Advisory Committee for Aeronautics
NASA	National Aeronautics and Space Administration
NSA	Nuclear Science Abstracts
NSF	National Science Foundation
NTIS	National Technical Information Service, U.S. Department of Commerce
OARS	OSTI Automated Retrieval System
ONR	Office of Naval Research
OSRD	Office of Scientific Research and Development
OSTI	Office of Scientific and Technical Information
OSTP	Office of Science and Technology Policy, Executive Office of the President
OTA	Office of Technology Assessment, U.S. Congress
OTS	Office of Technical Services
PB	Publications Board
Ph.D.	Doctor of Philosophy
P.L.	public law
RADCAP	R&D Contributions to Aviation Progress

R&D	research and development
R&T	research and technology
RDT&E	research, development, test, and evaluation
RECON	remote console
RIP	research in progress
S&T	science and technology; scientific and technical or technological
SATCOM	Scientific and Technical Communication
SCAN	Selected Current Aerospace Notices
SLIS	School of Library and Information Science Indiana University
SPSS[R]-PC	Statistical Package for the Social Sciences - Personal Computer
SRIM	Selected Research in Microfiche
STAR	Scientific and Technical Aerospace Reports
STI	scientific and technical information
STIF	Scientific and Technical Information Facility, National Aeronautics and Space Administration
STP	Science and Technology Project
TDM	total design method
TIC	Technical Information Center, U.S. Department of Energy
TIS	Technical Information Service
TRAC	Technical Report Awareness Circular
TRACES	Technology in Retrospect and Critical Events in Science
UMI	University Microfilms International
U.S.	United States

APPENDIX C
QUESTIONNAIRE AND ASSOCIATED CORRESPONDENCE



1

These data will help us determine the use, production, and importance of information by aerospace engineers and scientists.

1. Which of the following information sources do YOU use in performing YOUR present professional duties? (Circle number)

CONFERENCE/MEETING PAPERS	1 YES	2 NO
JOURNAL ARTICLES	1 YES	2 NO
IN-HOUSE TECHNICAL REPORTS*	1 YES	2 NO
GOVERNMENT TECHNICAL REPORTS	1 YES	2 NO

2. In terms of performing YOUR present professional duties, how important are the following information sources? One indicates the source is very important; 5 indicates that the source is not at all important. (Circle number)

	VERY IMPORTANT				VERY UNIMPORTANT
CONFERENCE/MEETING PAPERS	1	2	3	4	5
JOURNAL ARTICLES	1	2	3	4	5
IN-HOUSE TECHNICAL REPORTS	1	2	3	4	5
GOVERNMENT TECHNICAL REPORTS	1	2	3	4	5

3. In the past six months, approximately how many times did you use each of the following information sources in performing your present professional duties?

	In the past six months
CONFERENCE/MEETING PAPERS	______
JOURNAL ARTICLES	______
IN-HOUSE TECHNICAL REPORTS	______
GOVERNMENT TECHNICAL REPORTS	______

* In-house reports are those produced at your location/installation.

OPEN

The next few pages ask the factors that have influenced your use of certain information sources. For each reason, e.g., accessibility, please indicate by circling from 1 to 5 whether this reason greatly influenced or had no influence at all on your decision.

ABOUT CONFERENCE/MEETING PAPERS (If not used, go to Journal Articles)

To what extent was their use influenced by . . .	GREATLY INFLUENCED				NOT INFLUENCED
4. ACCESSIBILITY, that is, the ease of getting to the information source?	1	2	3	4	5
5. EASE OF USE, that is, the ease of comprehending or utilizing the information?	1	2	3	4	5
6. EXPENSE, that is, low cost in comparison to other information sources?.......	1	2	3	4	5
7. FAMILIARITY OR EXPERIENCE, that is, prior knowledge or previous use of the information source?	1	2	3	4	5
8. TECHNICAL QUALITY OR RELIABILITY, that is, the information sources were expected to be the best in terms of quality, accuracy, and reliability?	1	2	3	4	5
9. COMPREHENSIVENESS, that is, the expectation that the information source would provide broad coverage of the available knowledge?	1	2	3	4	5
10. RELEVANCE, that is, the expectation that a high percentage of the information retrieved from the source would be used?	1	2	3	4	5

ABOUT JOURNAL ARTICLES
(If not used, go to In-House Technical Reports.)

To what extent was their use influenced by . . .	GREATLY INFLUENCED				NOT INFLUENCED
11. ACCESSIBILITY, that is, the ease of getting to the information source?	1	2	3	4	5

ABOUT JOURNAL ARTICLES	GREATLY INFLUENCED			NOT INFLUENCED	
12. EASE OF USE, that is, the ease of comprehending or utilizing the information?	1	2	3	4	5
13. EXPENSE, that is, low cost in comparison to other information sources?	1	2	3	4	5
14. FAMILIARITY OR EXPERIENCE, that is, prior knowledge or previous use of the information source?	1	2	3	4	5
15. TECHNICAL QUALITY OR RELIABILITY, that is, the information sources were expected to be the best in terms of quality, accuracy, and reliability?	1	2	3	4	5
16. COMPREHENSIVENESS, that is, the expectation that the information source would provide broad coverage of the available knowledge?	1	2	3	4	5
17. RELEVANCE, that is, the expectation that a high percentage of the information retrieved from the source would be used?	1	2	3	4	5

ABOUT IN-HOUSE TECHNICAL REPORTS (If not used, go to Government Technical Reports.)

To what extent was their use influenced by . . .	GREATLY INFLUENCED			NOT INFLUENCED	
18. ACCESSIBILITY, that is, the ease of getting to the information source?	1	2	3	4	5
19. EASE OF USE, that is, the ease of comprehending or utilizing the information?	1	2	3	4	5
20. EXPENSE, that is, low cost in comparison to other information sources?	1	2	3	4	5
21. FAMILIARITY OR EXPERIENCE, that is, prior knowledge or previous use of the information source?	1	2	3	4	5

ABOUT IN-HOUSE TECHNICAL REPORTS	GREATLY INFLUENCED				NOT INFLUENCED
22. TECHNICAL QUALITY OR RELIABILITY, that is, the information sources were expected to be the best in terms of quality, accuracy, and reliability?	1	2	3	4	5
23. COMPREHENSIVENESS, that is, the expectation that the information source would provide broad coverage of the available knowledge?	1	2	3	4	5
24. RELEVANCE, that is, the expectation that a high percentage of the information retrieved from the source would be used?	1	2	3	4	5

ABOUT GOVERNMENT TECHNICAL REPORTS (If not used, go to Q32.)

To what extent was their use influenced by . . .	GREATLY INFLUENCED				NOT INFLUENCED
25. ACCESSIBILITY, that is, the ease of getting to the information source?	1	2	3	4	5
26. EASE OF USE, that is, the ease of comprehending or utilizing the information?	1	2	3	4	5
27. EXPENSE, that is, low cost in comparison to other information sources?	1	2	3	4	5
28. FAMILIARITY OR EXPERIENCE, that is, prior knowledge or previous use of the information source?	1	2	3	4	5
29. TECHNICAL QUALITY OR RELIABILITY, that is, the information sources were expected to be the best in terms of quality, accuracy, and reliability?	1	2	3	4	5
30. COMPREHENSIVENESS, that is, the expectation that the information source would provide broad coverage of the available knowledge?	1	2	3	4	5
31. RELEVANCE, that is, the expectation that a high percentage of the information retrieved from the source would be used?	1	2	3	4	5

5

In the past six months, what percentage of each of the following information sources were used for educational purposes (e.g., teaching, professional development); research; and for the management (e.g., planning, budgeting) of research? (If not used, skip to the next information source.)

	Educational	Research	Management	Other	Total
32. CONFERENCE/MEETING PAPERS	___%	___%	___%	___%	100%
33. JOURNAL ARTICLES	___%	___%	___%	___%	100%
34. IN-HOUSE TECHNICAL REPORTS	___%	___%	___%	___%	100%
35. GOVERNMENT TECHNICAL REPORTS	___%	___%	___%	___%	100%

36. Do YOU use the following types or kinds of information in performing YOUR present professional duties? (Circle numbers)

BASIC SCIENTIFIC AND TECHNOLOGY INFORMATION	1 YES	2 NO
IN-HOUSE TECHNICAL DATA	1 YES	2 NO
COMPUTER PROGRAMS	1 YES	2 NO
TECHNICAL SPECIFICATIONS	1 YES	2 NO
PRODUCT & PERFORMANCE CHARACTERISTICS	1 YES	2 NO

37. In the past six months, approximately what percentage of the **basic scientific and technology information** YOU used in performing your present professional duties were found in the following information sources? (Circle 1 if you did not use basic scientific and technology information.)

CONFERENCE/MEETING PAPERS	___%	1. I did not use basic scientific and technology information.
JOURNAL ARTICLES	___%	
IN-HOUSE TECHNICAL REPORTS	___%	
GOVERNMENT TECHNICAL REPORTS	___%	

38. In the past six months, approximately what percentage of the **in-house technical data** YOU used in performing your present professional duties were found in the following information sources? (Circle 1 if you did not use in-house technical data.)

CONFERENCE/MEETING PAPERS	___%	1. I did not use in-house technical data.
JOURNAL ARTICLES	___%	
IN-HOUSE TECHNICAL REPORTS	___%	
GOVERNMENT TECHNICAL REPORTS	___%	

39. In the past six months, approximately what percentage of the **computer programs** YOU used in performing your present professional duties were referenced or mentioned in the following information sources? (Circle 1 if you did not use computer programs.)

CONFERENCE/MEETING PAPERS	___%	1. I did not use computer programs.
JOURNAL ARTICLES	___%	
IN-HOUSE TECHNICAL REPORTS	___%	
GOVERNMENT TECHNICAL REPORTS	___%	

40. In the past six months, approximately what percentage of the **technical specifications** YOU used in performing your present professional duties were found in the following information sources? (Circle 1 if you did not use technical specifications.)

CONFERENCE/MEETING PAPERS	___%	1. I did not use technical specifications.
JOURNAL ARTICLES	___%	
IN-HOUSE TECHNICAL REPORTS	___%	
GOVERNMENT TECHNICAL REPORTS	___%	

41. In the past six months, approximately what percentage of the **product and performance** characteristics YOU used in performing your present professional duties were found in the following information sources? (Circle 1 if you did not use product and performance characteristics.)

CONFERENCE/MEETING PAPERS	___%	1. I did not use product and performance characteristics.
JOURNAL ARTICLES	___%	
IN-HOUSE TECHNICAL REPORTS	___%	
GOVERNMENT TECHNICAL REPORTS	___%	

These data will help determine the use of libraries and technical information centers, library and technical information services, and the use of information technology by aerospace engineers and scientists.

42. Does YOUR organization have a library and/or technical information center?

1 YES → 43. How far from it are you? ______ (Distance)

2 NO

44. How many times in the past six months have YOU:

______ VISITED A LIBRARY/TECHNICAL INFORMATION CENTER

______ SOUGHT THE HELP OF A STAFF MEMBER WHILE VISITING A LIBRARY/TECHNICAL INFORMATION CENTER

______ BEEN OFFERED ASSISTANCE BY A STAFF MEMBER WHILE VISITING A LIBRARY/TECHNICAL INFORMATION CENTER

7

- ______ REQUESTED SOMETHING IN WRITING OR ELECTRONICALLY FROM A LIBRARY/TECHNICAL INFORMATION CENTER
- ______ REQUESTED SOMETHING BY TELEPHONE FROM A LIBRARY/TECHNICAL INFORMATION CENTER
- ______ REQUESTED SOMETHING THROUGH A PROXY FROM A LIBRARY/TECHNICAL INFORMATION CENTER
- ______ REQUESTED SOMETHING OR HAD A LIBRARY REQUEST SOMETHING FROM SOME OTHER LIBRARY/TECHNICAL INFORMATION CENTER

45. Which of the following statements best describes any reasons YOU did not visit or request something from a library or technical information center in the past six months? (Circle numbers) If you DID visit or request something, skip to Q46.

HAD NO INFORMATION NEEDS	1 YES	2 NO
MY INFORMATION NEEDS WERE MORE EASILY MET SOME OTHER WAY	1 YES	2 NO
TRIED THEM ONCE OR TWICE BEFORE BUT THEY WERE NOT ABLE TO HELP ME	1 YES	2 NO
THE LIBRARY/TECHNICAL INFORMATION CENTER IS PHYSICALLY TOO FAR AWAY FROM WHERE I WORK	1 YES	2 NO
THE LIBRARY/TECHNICAL INFORMATION CENTER STAFF IS NOT COOPERATIVE OR HELPFUL	1 YES	2 NO
THE LIBRARY/TECHNICAL INFORMATION CENTER DOES NOT UNDERSTAND MY INFORMATION NEEDS	1 YES	2 NO
THE LIBRARY/TECHNICAL INFORMATION CENTER DOES NOT HAVE THE INFORMATION I NEED	1 YES	2 NO
I HAVE MY OWN PERSONAL LIBRARY AND DO NOT NEED A LIBRARY/TECHNICAL INFORMATION CENTER	1 YES	2 NO
THE LIBRARY/TECHNICAL INFORMATION CENTER IS TOO SLOW IN GETTING THE INFORMATION I NEED	1 YES	2 NO
WE HAVE TO PAY TO USE THE LIBRARY/TECHNICAL INFORMATION CENTER	1 YES	2 NO
WE ARE DISCOURAGED FROM USING THE LIBRARY/ TECHNICAL INFORMATION CENTER	1 YES	2 NO

46. In terms of performing YOUR present professional duties, how important is a library or technical information center? One indicates it is very important; 5 indicates it is not at all important. (Circle number)

VERY IMPORTANT				VERY UNIMPORTANT
1	2	3	4	5

47. In performing YOUR present professional duties, how do YOU view YOUR use of the following information technologies? (Circle numbers)

Information Technologies	I Already Use It	I Don't Use It, But May In the Future	I Don't Use It and Doubt If I Will
ELECTRONIC DATA BASES	1	2	3
ELECTRONIC NETWORKS	1	2	3
LASER DISC/VIDEO DISC/CD-ROM	1	2	3
MICROGRAPHICS AND MICROFILMS	1	2	3
TELECONFERENCING	1	2	3
VIDEO CONFERENCING	1	2	3
ELECTRONIC DATA BASES	1	2	3
FAX OR TELEX	1	2	3
ELECTRONIC BULLETIN BOARDS	1	2	3
ELECTRONIC MAIL	1	2	3
COMPUTER CASSETTE/ CARTRIDGE TAPES	1	2	3
FLOPPY DISKS	1	2	3
DESK-TOP/ELECTRONIC PUBLISHING	1	2	3
VIDEO TAPE	1	2	3
MOTION PICTURE FILM	1	2	3
AUDIO TAPES AND CASSETTES	1	2	3

These data will help us determine how aerospace engineers and scientists use information to solve technical problems.

48. Briefly describe the most important technical project, task, or problem you have worked on in the past six months.

____
____
____
____
____
____

49. In completing your most important technical project, task, or problem during the past six months, what steps did you follow in looking for the information YOU needed to complete the project, task or to solve the problem? (Enter "1" beside the first step, "2" beside the second step, and so forth.)

STEP

___ I SEARCHED A DATABASE OR HAD IT SEARCHED FOR ME

___ I CHECKED WITH A LIBRARIAN/TECHNICAL INFORMATION SPECIALIST OUTSIDE MY ORGANIZATION

___ I CHECKED WITH A LIBRARIAN/TECHNICAL INFORMATION SPECIALIST IN MY ORGANIZATION

___ I CONSULTED LIBRARY SOURCES (E.G., CONFERENCE/MEETING PAPERS, JOURNAL ARTICLES, TECHNICAL REPORTS)

___ I SPOKE WITH A KEY PERSON OUTSIDE MY ORGANIZATION TO WHOM I USUALLY LOOK FOR NEW INFORMATION

___ I SPOKE WITH A KEY PERSON IN MY ORGANIZATION TO WHOM I USUALLY LOOK FOR NEW INFORMATION

___ I DISCUSSED THE PROBLEM WITH MY SUPERVISOR

___ I DISCUSSED THE PROBLEM INFORMALLY WITH A COLLEAGUE(S)

___ I USED MY PERSONAL STORE OF TECHNICAL INFORMATION, INCLUDING SOURCES I KEEP IN MY OFFICE

50. Which of the following BEST characterizes the technical project, task, or problem in Q48? (Circle one number)

1 EDUCATIONAL (e.g., for professional development, teaching, current awareness, or preparation of a lecture/presentation)

2 RESEARCH (either basic or applied)

3 DESIGN

4 DEVELOPMENT

5 MANUFACTURING

6 PRODUCTION

7 MANAGEMENT (e.g., planning, budgeting, and management of research)

8 COMPUTER APPLICATIONS

51. Were government technical reports used to complete the technical project or task or in solving the problem in Q48?

1 YES 2 NO (If NO, then skip to Q56.)

52. How did you find out about the government technical report(s)? (Circle numbers)

I USED MY PERSONAL STORE OF TECHNICAL INFORMATION	1 YES	2 NO
BY INTENTIONAL SEARCH OF LIBRARY RESOURCES	1 YES	2 NO
BY ASKING A COLLEAGUE IN MY ORGANIZATION	1 YES	2 NO
BY ASKING A COLLEAGUE OUTSIDE OF MY ORGANIZATION	1 YES	2 NO
BY ASKING A LIBRARIAN OR TECHNICAL INFORMATION SPECIALIST	1 YES	2 NO
BY ASKING MY SUPERVISOR	1 YES	2 NO
SOMEONE INFORMED ME WITHOUT MY ASKING	1 YES	2 NO
BY ACCIDENT, BROWSING, OR LOOKING FOR OTHER INFORMATION	1 YES	2 NO
I SEARCHED A DATABASE OR HAD IT SEARCHED FOR ME	1 YES	2 NO

53. At what stage in the technical project or task or in solving the problem did YOU use the government technical report(s)? (Circle number)

THROUGHOUT THE DURATION OF THE TECHNICAL PROJECT, TASK, OR TECHNICAL PROBLEM	1 YES	2 NO
NEAR THE BEGINNING	1 YES	2 NO
NEAR THE MIDDLE	1 YES	2 NO
NEAR THE END	1 YES	2 NO

54. To what degree was the information found in the government technical report(s) effective in completing the technical project or task or in solving the problem? (Circle number)

EXTREMELY EFFECTIVE			EXTREMELY INEFFECTIVE	
1	2	3	4	5

55. To what degree was the information found in the government technical report(s) efficient (e.g., time spent, cost) in completing the technical project or task or in solving the problem? (Circle number)

EXTREMELY EFFICIENT			EXTREMELY INEFFICIENT	
1	2	3	4	5

These data will help determine if aerospace engineers and scientists with different backgrounds have different information practices.

56. Which is the highest level of education that YOU have completed? (Circle one number)

1 NO DEGREE
2 TECHNICAL OR VOCATIONAL DEGREE
3 BACHELOR'S DEGREE
4 MASTER'S DEGREE
5 DOCTORATE
6 POST DOCTORATE
7 OTHER (specify)_____

57. Next, compare YOUR educational preparation and present duties. (Circle number)

Educational Preparation	Present Professional Duties
1 ENGINEER	1 ENGINEER
2 SCIENTIST	2 SCIENTIST
3 OTHER (specify)_____	3 OTHER (specify)_____

58. YOUR years of professional work experience in aerospace: ___ YEARS.

59. The type of organization where YOU work. (Circle one number)

1 ACADEMIC
2 GOVERNMENT (DOD)
3 GOVERNMENT (NASA)
4 GOVERNMENT (OTHER)
5 INDUSTRIAL
6 NOT-FOR-PROFIT
7 RETIRED OR NOT EMPLOYED
8 OTHER (specify)_____

60. What is YOUR primary professional duty? (Circle only one number.)

1 ACADEMIC/TEACHING (may include research)
2 RESEARCH
3 ADMINISTRATIVE/MANAGEMENT (for profit sector)
4 TECHNICAL ADMINISTRATIVE/ MANAGEMENT (for profit sector)
5 ADMINISTRATIVE/MANAGEMENT (Government, not-for-profit)
6 TECHNICAL ADMINISTRATIVE/ MANAGEMENT (Government, not-for-profit)
7 DESIGN/DEVELOPMENT/RDTE
8 MANUFACTURING/PRODUCTION
9 MARKETING/SALES
10 SERVICE/MAINTENANCE
11 OTHER (specify)_____

61. What is YOUR principal AIAA interest group? (Circle only one number)

1 AEROSPACE SCIENCES
2 AIRCRAFT SYSTEMS
3 INFORMATION & LOGISTIC SYSTEMS
4 PROPULSION & ENERGY
5 SPACE & MISSILE SYSTEMS
6 STRUCTURES, DESIGN & TEST
7 OTHER (specify)_____

62. Which of the following best characterizes YOUR area of work or characterizes the application of YOUR work? (Circle one number)

1 AERONAUTICS
2 ASTRONAUTICS
3 ENGINEERING
4 GEOSCIENCES
5 LIFE SCIENCES
6 MATHEMATICAL & COMPUTER SCIENCES
7 MATERIALS & CHEMISTRY
8 PHYSICS
9 SPACE SCIENCES
10 OTHER (specify)_____

63. Is ANY of YOUR current work funded by the Federal government? (Circle number)

1 YES
2 NO

64. Who supplies the largest proportion of funds for YOUR current research/project(s)? (Circle number)

1 FEDERAL GOVERNMENT
2 PRIVATE INDUSTRY
3 EDUCATIONAL INSTITUTION
4 NOT-FOR-PROFIT INSTITUTION
5 OTHER (specify)_____

(OVER)

65. Is there anything else you would care to say regarding this research?

Mail to:
1022 East Third Street
Indiana University
Bloomington, IN 47401

May 15, 1989

«title» «name»
«street» «address»
«city» «state» «zip»

Dear «title» «name»

Frequently, we are involved in discussions about how to best make technical information available to engineers and scientists in aerospace. It has been apparent in these discussions that there is a lot we do not know about the information needs of aerospace engineers and scientists like yourself and what we can do to better meet those needs. Increased understanding of the flow of technical information in the aerospace industry can contribute to increasing productivity, stimulating innovation, and improving and maintaining the professional competence of aeronautical engineers and scientists.

You are one of a small, but carefully selected, number of aeronautical engineers and scientists who, as AIAA members, are being asked to provide input on their information-seeking habits and practices. For the results of this study to accurately reflect the general population of aeronautical engineers and scientists, it is important that each member of the sample population participate in the study. We think it will take only 20 minutes to complete.

You may be assured of complete confidentiality. The number on the questionnaire is used only to identify those who responded. Only the composite results of the study will be made available to federal agencies involved in aeronautical research and development. These results will help the agencies to develop information policy and systems for the aerospace industry.

You can receive a summary of the results by writing "copy of results requested" on the back of the return envelope. If you have any questions, you can reach me by telephone at (812) 855-2848.

Thank you for your assistance.

Sincerely,

Herbert S. White, Dean
School of Library and Information Science

INDIANA UNIVERSITY
School of Library
and Information Science
Bloomington, IN 47405

July 1989

Dear AIAA Member:

Last week a questionnaire seeking your opinion about information-seeking practices was sent to you from the School of Library and Information Science at Indiana University. If you have already completed it and returned it, please accept our sincere thanks. You have made it easier for us to complete our research.

If you have not completed and returned the questionnaire to the Center for Survey Research, please do so today. It is essential for us to have responses from all questionnaires sent out if we are to present an accurate assessment of technical information use.

If by some chance you have not received the questionnaire, or if it has been misplaced, please call John Kennedy at the Center for Survey Research (812-855-2573). He will send a replacement questionnaire immediately. If you have any questions about the survey, please call me (812-855-2848).

Sincerely,

Herbert S. White

Herbert S. White, Dean

June 30, 1989

«name»
«address»
«city», «state» «zip»

Dear «title» «lname»:

About four weeks ago, we sent you a questionnaire that asked your opinions about the information needs of aerospace engineers and scientists like yourself. As of today, we have not yet received your reply.

We feel that input from all of the selected members of the AIAA is essential if we are to prepare a thorough report on your information-seeking habits and practices. The AIAA has endorsed this research and your responses are crucial to our work.

Please return the enclosed questionnaire as soon as possible but no later than August 28. A prompt reply will assist us in completing the report. If you would like a copy of the report, indicate so by writing "copy of results requested" on the back of the return envelope.

Your cooperation is greatly appreciated. If you have any questions about the survey, please contact John Kennedy, the survey director, at 812-855-2573.

Thank you for your assistance.

Sincerely,

Herbert S. White, Dean
School of Library and Information Science

August 7, 1989

«name»
«street»
«city», «state» «zip»

Dear «title» «lname»:

As you may recall, we are conducting a study on the information-gathering needs of aerospace engineers and scientists. The large number of questionnaires that have been returned is very encouraging. However, we have not yet received yours.

Our past experiences suggest that those of you who have not yet sent in your questionnaires may hold quite different views on the use of government technical reports than those who have. The accuracy of the results depends upon having the opinions of all of you who were selected for this research.

As this is the first study of its kind, the results are of particular importance to federal agencies involved in aerospace research and development. The usefulness of our results depends on how accurately we are able to describe the information needs of engineers and scientists. It is for these reasons that I urge you to complete and return the enclosed questionnaire as quickly as possible.

If you would like a copy of the results, simply write on the back of the return envelope "copy of results requested." Your contribution to the success of this study will be greatly appreciated.

Sincerely,

Herbert S. White, Dean
School of Library and Information Science

NASA

National Aeronautics and
Space Administration

Washington, D.C.
20546

Reply to Attn of

September 8, 1989

«name»
«street»
«city», «state» «zip»

Dear «title» «lname»:

I am writing this letter to request your assistance with our research. NASA is very interested in obtaining data on the information-gathering practices of aerospace engineers and scientists. As part of this research, you will receive a questionnaire from the Indiana University Center for Survey Research that asks about your information needs.

The AAIA has provided the sample of names for this project. So that our research will be scientifically valid and reliable, it is vital that every person who was selected for this research take the 15-20 minutes necessary to fill out and return the questionnaire.

Of course, not all AAIA members are active in aerospace. Therefore, we have provided a postcard so that you can help us determine who should not receive the questionnaire that will be sent in two weeks. If applicable, please check the appropriate box and return the postcard as soon as possible.

I appreciate that you have a busy schedule. That is why it is important that you give us your opinions. By doing so we will be better able to meet your needs and save you time in the future. This research will assist us in providing you with the information that would be most useful to you.

If you wish to talk about the survey, please contact the survey director, John Kennedy. His telephone number is (812)855-2573. He will be happy to answer your questions.

Thank you for your time and cooperation.

Sincerely,

Randolph A. Graves, Director
Aerodynamics Division

NASA
National Aeronautics and
Space Administration

Langley Research Center
MS 180A
Hampton, Virginia 23665-5225

Official Business
Penalty for Private Use, $300

U.S.MAIL

Postage and Fees Paid
National Aeronautics and
Space Administration
NASA-451

Center for Survey Research
Indiana University
1022 East Third Street
Bloomington, IN 47405

Please check the appropriate blanks

_____ Please send me a questionnaire
_____ I am not involved in aerospace research
_____ I do not wish to participate in the study
_____ Please send me a copy of the results

Thank you
for your response

APPENDIX D
DESCRIPTIVE DATA TABLES FOR (1) EDUCATION, CAREER, AND WORK EXPERIENCE AND (2) INFORMATION SOURCES USED TO COMPLETE MOST IMPORTANT TECHNICAL PROJECT, TASK, OR TECHNICAL PROBLEM

Table D1. Relationship of Education and Technical Information Products Used

Information product	Percentage using product with -			Overall percentage using product[a] (n = 1954)
	Bachelor's degree or lower (n = 562)	Master's degree (n = 774)	Doctoral degree or higher (n = 618)	
Conference-Meeting papers	94.1	97.2	99.7	97.1
Journal articles	93.2	97.0	99.2	96.6
In-house technical reports	98.4	98.6	98.9	98.6
U.S. Government technical reports	96.1	97.8	98.4	97.5

[a]Note that 63 individuals did not specify their level of education.

Table D2. Relationship of Career and Technical Information Products Used

Information product	Percentage using product as -			Overall percentage using product[a] (n = 1963)
	Engineer (n = 1325)	Scientist (n = 168)	Other (n = 470)	
Conference-Meeting papers	97.4	98.8	96.0	97.2
Journal articles	96.7	97.6	96.6	96.7
In-house technical reports	98.8	99.4	98.1	98.7
U.S. Government technical reports	97.7	98.8	96.6	97.6

[a]Note that 53 individuals did not specify their educational preparation.

Table D3. Relationship of Work Experience and Technical Information Products Used

Information product	Number (percentage) using product for respondents with -					Overall percentage using product[a] (n = 1934)
	1-5 years work exp. (n = 226)	6-10 years work exp. (n = 293)	11-20 years work exp. (n = 425)	21-30 years work exp. (n = 513)	Over 30 years work exp. (n = 477)	
Conference-Meeting papers	217 (96.0)	284 (96.9)	417 (98.1)	500 (97.5)	459 (96.2)	97.1
Journal articles	215 (95.1)	282 (96.2)	415 (97.6)	500 (97.5)	457 (95.8)	96.6
In-house technical reports	223 (98.7)	288 (98.3)	420 (98.8)	507 (98.8)	468 (98.1)	98.6
U.S. Government technical reports	220 (97.3)	284 (96.9)	415 (97.6)	503 (98.1)	462 (96.9)	97.4

[a]Note that 82 individuals did not specify their years of work experience.

Table D4. Relationship of Education and Importance of Technical Information Products

Information product	Average[a] (mean) importance rating for respondents with -			Overall average importance rating[b] (n = 1954)
	Bachelor's degree or lower (n = 562)	Master's degree (n = 774)	Doctoral degree or higher (n = 618)	
Conference-Meeting papers	3.10	3.42	4.06	3.54[c]
Journal articles	3.01	3.33	4.21	3.52[d]
In-house technical reports	4.05	4.01	3.43	3.84[e]
U.S. Government technical reports	3.39	3.58	3.54	3.51[f]

[a]A 1 to 5 point scale was used to measure importance, with "1" being the lowest possible importance and "5" being the highest possible importance. Hence, the higher the average (mean), the greater the importance of the product. [b]Note that 62 individuals did not specify their level of education. [c]Note that 71 individuals did not rate conference-meeting papers. [d]Note that 73 individuals did not rate journal articles. [e]Note that 86 individuals did not rate in-house technical reports. [f]Note that 74 individuals did not rate U.S. Government technical reports.

Table D5. Relationship of Career and Importance of Technical Information Products

Information product	Average[a] (mean) importance rating for -			Overall average importance rating[b] (n = 1963)
	Engineer (n = 1325)	Scientist (n = 168)	Other (n = 470)	
Conference-Meeting papers	3.50	4.19	3.39	3.53[c]
Journal articles	3.48	4.31	3.33	3.52[d]
In-house technical reports	3.95	3.34	3.69	3.84[e]
U.S. Government technical reports	3.58	3.52	3.31	3.51[f]

[a]A 1 to 5 point scale was used to measure importance, with "1" being the lowest possible importance and "5" being the highest possible importance. Hence, the higher the average (mean), the greater the importance of the product. [b]Note that 53 individuals did not specify their present professional duty. [c]Note that 69 individuals did not rate conference-meeting papers. [d]Note that 72 individuals did not rate journal articles. [e]Note that 83 individuals did not rate in-house technical reports. [f]Note that 73 individuals did not rate U.S. Government technical reports.

Table D6. Relationship of Work Experience and Importance of Technical Information Products

Information product	Average[a] (mean) importance rating for respondents with -					Overall average importance rating[b] (n = 1934)
	1-5 years work exp. (n = 226)	6-10 years work exp. (n = 293)	11-20 years work exp. (n = 425)	21-30 years work exp. (n = 513)	Over 30 years work exp. (n = 477)	
Conference-Meeting papers	3.28	3.59	3.56	3.59	3.52	3.53[c]
Journal articles	3.39	3.57	3.59	3.53	3.45	3.51[d]
In-house technical reports	3.68	3.72	3.89	3.79	4.02	3.84[e]
U.S. Government technical reports	3.37	3.39	3.45	3.52	3.71	3.51[f]

[a]A 1 to 5 point scale was used to measure importance, with "1" being the lowest possible importance and "5" being the highest possible importance. Hence, the higher the average (mean), the greater the importance of the product. [b]Note that 82 individuals did not specify their years of work experience. [c]Note that 69 individuals did not rate conference-meeting papers. [d]Note that 72 individuals did not rate journal articles. [e]Note that 81 individuals did not rate in-house technical reports. [f]Note that 72 individuals did not rate U.S. Government technical reports.

Table D7. Relationship of Education and Frequency of Use of Technical Information Products

Information product	Average number of times (median) product used in 6-month period for respondents with -			Overall average number of times (median) product used[a] (n = 1954)
	Bachelor's degree or lower (n = 562)	Master's degree (n = 774)	Doctoral degree or higher (n = 618)	
Conference-Meeting papers	8.73 (3.00)	9.85 (4.00)	17.30 (8.00)	12.14 (4.00)[b]
Journal articles	7.97 (3.00)	10.36 (4.00)	24.73 (10.00)	14.90 (5.00)[c]
In-house technical reports	24.25 (6.00)	19.37 (6.50)	17.27 (5.00)	20.23 (6.00)[d]
U.S. Government technical reports	9.63 (4.00)	12.02 (5.00)	12.53 (5.00)	11.53 (5.00)[e]

[a]Note that 62 individuals did not specify their level of education. [b]Note that 333 individuals did not specify the frequency of use of conference-meeting papers. [c]Note that 354 individuals did not specify the frequency of use of journal articles. [d]Note that 328 individuals did not specify frequency of use of in-house technical reports. [e]Note that 375 individuals did not specify the frequency of use of U.S. Government technical reports.

Table D8. Relationship of Career and Frequency of Use of Technical Information Products

Information product	Average number of times (median) product used in 6-month period for -			Overall average number of times (median) product used[a] (n = 1963)
	Engineer (n = 1325)	Scientist (n = 168)	Other (n = 470)	
Conference-Meeting papers	10.30 (4.00)	21.86 (10.00)	14.20 (4.00)	12.31 (4.00)[b]
Journal articles	11.78 (6.00)	37.28 (12.00)	15.13 (6.00)	15.07 (6.00)[c]
In-house technical reports	19.52 (6.00)	21.96 (5.00)	21.71 (6.00)	20.22 (6.00)[d]
U.S. Government technical reports	11.68 (5.00)	16.56 (5.00)	9.01 (4.00)	11.52 (5.00)[e]

[a]Note that 53 individuals did not specify their present professional duty. [b]Note that 338 individuals did not specify the frequency of use of conference-meeting papers. [c]Note that 359 individuals did not specify the frequency of use of journal articles. [d]Note that 327 individuals did not specify frequency of use of in-house technical reports. [e]Note that 373 individuals did not specify the frequency of use of U.S. Government technical reports.

Table D9. Relationship of Work Experience and Frequency of Use of Technical Information Products

Information product	Average number of times (median) product used in 6-month period for respondents with -					Overall average number of times (median) product used[a] (n = 1934)
	1-5 years work exp. (n = 226)	6-10 years work exp. (n = 293)	11-20 years work exp. (n = 425)	21-30 years work exp. (n = 513)	Over 30 years work exp. (n = 477)	
Conference-Meeting papers	14.51 (5.00)	15.77 (5.00)	11.61 (5.00)	11.36 (4.00)	10.85 (4.00)	12.30 (4.00)[b]
Journal articles	15.32 (5.00)	90.91 (5.00)	13.59 (5.00)	16.22 (5.00)	11.27 (5.00)	15.02 (5.00)[c]
In-house technical reports	19.24 (5.00)	20.00 (5.00)	18.00 (6.00)	24.78 (6.00)	17.71 (6.00)	20.14 (6.00)[d]
U.S. Government technical reports	11.93 (3.00)	10.87 (4.00)	9.76 (4.00)	13.78 (5.00)	10.66 (5.00)	11.48 (5.00)[e]

[a]Note that 82 individuals did not specify their years of work experience. [b]Note that 333 individuals did not specify the frequency of use of conference-meeting papers. [c]Note that 353 individuals did not specify the frequency of use of journal articles. [d]Note that 318 individuals did not specify the frequency of use of in-house technical reports. [e]Note that 365 individuals did not specify the frequency of use of U.S. government technical reports.

Table D10. Relationship of Education and Factors Affecting the Use of U.S. Government Technical Reports

Selection factor	Average[a] (mean) influence of factor on use for respondents with - Bachelor's degree or lower (n = 540)	Master's degree (n = 757)	Doctoral degree or higher (n = 608)	Overall average influence of factor[b] (n = 1905)
Accessibility	3.50	3.73	3.66	3.65[c]
Ease of use	3.36	3.44	3.30	3.38[d]
Expense	2.54	2.50	2.52	2.52[e]
Familiarity or experience	3.48	3.53	3.52	3.51[f]
Technical quality or reliability	3.79	3.79	3.63	3.73[g]
Comprehensiveness	3.64	3.57	3.46	3.55[h]
Relevance	3.87	3.94	3.86	3.90[i]

[a]A 1 to 5 point scale was used to measure influence, with "1" being the lowest possible influence and "5" being the highest possible influence. Hence, the higher the average (mean), the greater the influence. [b]Note that 62 individuals did not specify their level of education and that 49 individuals did not use U.S. Government technical reports and were not asked these questions. [c]Note that 240 individuals did not rate accessibility. [d]Note that 244 individuals did not rate ease of use. [e]Note that 247 individuals did not rate expense. [f]Note that 240 individuals did not rate familiarity or experience. [g]Note that 235 individuals did not rate technical quality or reliability. [h]Note that 241 individuals did not rate comprehensiveness. [i]Note that 237 individuals did not rate relevance.

Table D11. Relationship of Career and Factors Affecting the Use of U.S. Government Technical Reports

Selection factor	Average[a] (mean) influence of factor on use for -			Overall average influence of factor[b] (n = 1915)
	Engineer (n = 1295)	Scientist (n = 166)	Other (n = 454)	
Accessibility	3.65	3.53	3.67	3.64[c]
Ease of use	3.38	3.23	3.38	3.37[d]
Expense	2.49	2.54	2.57	2.51[e]
Familiarity or experience	3.50	3.47	3.59	3.51[f]
Technical quality or reliability	3.76	3.61	3.71	3.73[g]
Comprehensiveness	3.56	3.39	3.59	3.55[h]
Relevance	3.90	3.79	3.92	3.89[i]

[a]A 1 to 5 point scale was used to measure influence, with "1" being the lowest possible influence and "5" being the highest possible influence. Hence, the higher the average (mean), the greater the influence. [b]Note that 53 individuals did not specify their present professional duty and that 48 individuals did not use U.S. Government technical reports and were not asked these questions. [c]Note that 240 individuals did not rate accessibility. [d]Note that 243 individuals did not rate ease of use. [e]Note that 248 individuals did not rate expense. [f]Note that 341 individuals did not rate familiarity or experience. [g]Note that 235 individuals did not rate technical quality or reliability. [h]Note that 241 individuals did not rate comprehensiveness. [i]Note that 238 individuals did not rate relevance.

Table D12. Relationship of Work Experience and Factors Affecting the Use of U.S. Government Technical Reports

Selection factor	Average[a] (mean) influence of factor on use for respondents with -					Overall average influence of factor[b] (n = 1884)
	1-5 years work exp. (n = 220)	6-10 years work exp. (n = 284)	11-20 years work exp. (n = 415)	21-30 years work exp. (n = 503)	Over 30 years work exp. (n = 462)	
Accessibility	3.61	3.56	3.68	3.63	3.69	3.64[c]
Ease of use	3.30	3.35	3.36	3.41	3.39	3.37[d]
Expense	2.42	2.43	2.62	2.48	2.52	2.51[e]
Familiarity or experience	3.29	3.67	3.54	3.57	3.60	3.52[f]
Technical quality or reliability	3.84	3.49	3.67	3.73	3.78	3.73[g]
Comprehensiveness	3.64	3.87	3.52	3.55	3.60	3.56[h]
Relevance	3.90	3.79	3.89	3.90	3.91	3.90[i]

[a]A 1 to 5 point was used to measure influence, with "1" being the lowest possible influence and "5" being the highest possible influence. Hence, the higher the average (mean), the greater the influence of the factor. [b]Note that 82 individuals did not specify their years of work experience and that 50 individuals did not use U.S. Government technical reports and were not asked these questions. [c]Note that 237 individuals did not rate accessibility. [d]Note that 240 individuals did not rate ease of use. [e]Note that 245 individuals did not rate expense. [f]Note that 238 individuals did not rate familiarity or experience. [g]Note that 232 individuals did not rate technical quality or reliability. [h]Note that 239 individuals did not rate comprehensiveness. [i]Note that 235 individuals did not rate relevance.

Table D13. Relationship of Education and Use of Conference-Meeting Papers

Purpose	Average percentage of use for respondents with -			Overall average percentage of use[a,b,c] (n = 1434)
	Bachelor's degree or lower (n = 340)	Master's degree (n = 545)	Doctoral degree or higher (n = 549)	
Education	32.36	25.75	17.28	24.07
Research	40.23	47.32	66.61	53.03
Management	19.49	18.03	10.62	15.54
Other	7.93	8.90	5.50	7.37

[a]Note that 62 individuals did not specify their level of education. [b]Note that 73 individuals did not use conference-meeting papers in the past 6 months. [c]Note that 359 individuals were not sure of the percentage of use for education, research, management, or other.

Table D14. Relationship of Career and Use of Conference-Meeting Papers

Purpose	Average percentage of use for -			Overall average percentage of use [a,b,c]
	Engineer (n = 969)	Scientist (n = 146)	Other (n = 324)	(n = 1439)
Education	25.47	15.03	24.08	24.09
Research	54.88	73.90	39.32	53.31
Management	11.79	8.19	29.13	15.33
Other	7.85	2.88	7.47	7.26

[a]Note that 53 individuals did not specify their present professional duty. [b]Note that 71 individuals did not use conference-meeting papers in the past 6 months. [c]Note that 453 individuals were not sure of the percentage of use for education, research, management, or other.

Table D15. Relationship of Work Experience and Use of Conference-Meeting Papers

Purpose	Average percentage of use for respondents with -					Overall average percentage of use [a,b,c]
	1-5 years work exp. (n = 154)	6-10 years work exp. (n = 237)	11-20 years work exp. (n = 337)	21-30 years work exp. (n = 386)	Over 30 years work exp. (n = 308)	(n = 1422)
Education	31.58	27.43	23.73	21.47	22.48	24.31
Research	57.78	61.05	55.43	49.88	46.09	53.09
Management	4.11	6.45	14.39	21.33	21.33	15.34
Other	6.53	5.07	6.45	7.32	10.10	7.25

[a]Note that 82 individuals did not specify their years of work experience. [b]Note that 73 individuals did not use conference-meeting papers in the past 6 months. [c]Note that 439 individuals were not sure of the percentage of use for education, research, management, or other.

Table D16. Relationship of Education and Use of Journal Articles

Purpose	Average percentage of use for respondents with -			Overall average percentage of use[a,b,c] (n = 1411)
	Bachelor's degree or lower (n = 333)	Master's degree (n = 532)	Doctoral degree or higher (n = 546)	
Education	37.92	30.04	19.84	27.95
Research	35.53	45.86	66.69	51.48
Management	16.38	15.93	8.72	13.25
Other	10.18	8.16	4.75	7.32

[a]Note that 62 individuals did not specify their level of education. [b]Note that 79 individuals did not use journal articles in the past 6 months. [c]Note that 464 individuals were not sure of the percentage of use for education, research, management, or other.

Table D17. Relationship of Career and Use of Journal Articles

Purpose	Average percentage of use for -			Overall average percentage of use[a,b,c] (n = 1414)
	Engineer (n = 941)	Scientist (n = 145)	Others (n = 328)	
Education	29.66	17.37	28.00	28.02
Research	52.90	72.21	39.01	51.66
Management	9.95	7.76	24.38	13.07
Other	7.49	2.66	8.61	7.25

[a]Note that 53 individuals did not specify their present professional duty. [b]Note that 79 individuals did not use journal articles in the past 6 months. [c]Note that 470 individuals were not sure of the percentage of use for education, research, management, or other.

Table D18. Relationship of Work Experience and Use of Journal Articles

Purpose	Average percentage of use for respondents with -					Overall average percentage of use[a,b,c] (n = 1396)
	1-5 years work exp. (n = 158)	6-10 years work exp. (n = 225)	11-20 years work exp. (n = 334)	21-30 years work exp. (n = 386)	Over 30 years work exp. (n = 293)	
Education	36.90	31.76	26.00	26.69	25.51	28.25
Research	52.35	59.79	54.31	48.56	44.77	51.38
Management	4.59	4.07	13.39	17.18	18.86	13.09
Other	6.16	4.39	6.30	7.57	10.86	7.28

[a]Note that 82 individuals did not specify their years of work experience. [b]Note that 79 individuals did not use journal articles in the past 6 months. [c]Note that 459 individuals were not sure of the percentage of use for education, research, management, or other.

Table D19. Relationship of Education and Use of In-House Technical Reports

Purpose	Average percentage of use for respondents with -			Overall average percentage of use[a,b,c] (n = 1420)
	Bachelor's degree or lower (n = 393)	Master's degree (n = 589)	Doctoral degree or higher (n = 438)	
Education	18.87	16.75	11.91	15.85
Research	46.52	49.32	64.10	53.10
Management	23.48	24.22	16.80	21.73
Other	11.13	9.70	7.18	9.32

[a]Note that 62 individuals did not specify their level of education. [b]Note that 37 individuals did not use in-house technical reports in the past 6 months. [c]Note that 497 individuals were not sure of the percentage of use for education, research, management, or other.

Table D20. Relationship of Career and Use of In-House Technical Reports

Purpose	Average percentage of use for -			Overall average percentage of use [a,b,c] (n = 1428)
	Engineer (n = 976)	Scientist (n = 120)	Other (n = 332)	
Education	16.17	11.78	16.64	15.91
Research	57.15	71.39	34.75	53.14
Management	16.40	11.00	40.61	21.58
Other	10.28	5.83	8.01	9.38

[a]Note that 53 individuals did not specify their present professional duty. [b]Note that 36 individuals did not use in-house technical reports in the past 6 months. [c]Note that 499 individuals were not sure of the percentage of use for education, research, management, or other.

Table D21. Relationship of Work Experience and Use of In-House Technical Reports

Purpose	Average percentage of use for respondents with -					Overall average percentage of use [a,b,c] (n = 1411)
	1-5 years work exp. (n = 155)	6-10 years work exp. (n = 217)	11-20 years work exp. (n = 337)	21-30 years work exp. (n = 382)	Over 30 years work exp. (n = 320)	
Education	20.79	17.12	14.84	15.71	14.94	16.12
Research	58.57	62.95	55.98	47.91	46.78	53.07
Management	10.65	10.71	22.01	27.86	26.12	21.54
Other	10.00	9.22	7.17	8.52	12.16	9.29

[a]Note that 82 individuals did not specify their years of work experience. [b]Note that 37 individuals did not use in-house technical reports in the past 6 months. [c]Note that 486 individuals were not sure of the percentage of use for education, research, management, or other.

Table D22. Relationship of Education and Use of U.S. Government Technical Reports

Purpose	Average percentage of use for respondents with -			Overall average percentage of use [a,b,c] (n = 1410)
	Bachelor's degree or lower (n = 342)	Master's degree (n = 573)	Doctoral degree or higher (n = 495)	
Education	22.34	19.48	13.55	18.09
Research	48.05	50.03	67.76	55.77
Management	19.87	20.19	12.42	17.38
Other	9.74	10.31	6.27	8.75

[a]Note that 62 individuals did not specify their level of education. [b]Note that 61 individuals did not use U.S. government technical reports in the past 6 months. [c]Note that 483 individuals were not sure of the percentage of use for education, research, management, or other.

Table D23. Relationship of Career and Use of U.S. Government Technical Reports

Purpose	Average percentage of use for -			Overall average percentage of use [a,b,c] (n = 1419)
	Engineer (n = 953)	Scientist (n = 144)	Other (n = 322)	
Education	18.93	13.89	17.75	18.51
Research	58.76	71.65	39.92	55.79
Management	13.21	9.77	32.26	17.18
Other	9.10	4.69	10.07	8.88

[a]Note that 53 individuals did not specify their present professional duty. [b]Note that 61 individuals did not use U.S. government technical reports in the past 6 months. [c]Note that 483 individuals were not sure of the percentage of use for education, research, management, or other.

Table D24. Relationship of Work Experience and Use of U.S. Government Technical Reports

Purpose	Average percentage of use for respondents with -					Overall average percentage of use [a,b,c] (n = 1397)
	1-5 years work exp. (n = 156)	6-10 years work exp. (n = 218)	11-20 years work exp. (n = 332)	21-30 years work exp. (n = 386)	Over 30 years work exp. (n = 305)	
Education	23.48	18.49	16.94	16.72	18.16	18.12
Research	59.15	67.17	57.26	51.35	49.80	55.76
Management	6.34	8.40	12.19	23.72	21.41	17.33
Other	11.03	5.94	8.62	8.21	10.62	8.79

[a]Note that 82 individuals did not specify their years of work experience. [b]Note that 62 individuals did not use U.S. government technical reports in the past 6 months. [c]Note that 475 individuals were not sure of the percentage of use for education, research, management, or other.

Table D25. Order in Which Information Sources Were Used by Respondents to Complete Most Important Technical Project, Task, or Technical Problem

Source	Number (percentage) respondents using step -									Total respondents[a] (n = 2016)
	1	2	3	4	5	6	7	8	9	
Used personal store of technical information	588 (39.6)	267 (18.0)	274 (18.5)	173 (11.7)	95 (6.4)	47 (3.2)	25 (1.7)	5 (0.3)	9 (0.6)	1483 [b]
Discussed problem with a colleague in my organization	203 (15.2)	443 (32.5)	323 (24.2)	196 (14.7)	98 (7.3)	45 (3.4)	17 (1.3)	15 (1.1)	4 (0.3)	1344 [c]
Discussed problem with my supervisor	247 (29.5)	140 (16.7)	127 (15.2)	101 (12.1)	85 (10.1)	45 (5.4)	26 (3.1)	18 (2.1)	49 (5.8)	838 [d]
Discussed problem with a colleague outside my organization	86 (9.2)	154 (16.5)	158 (17.0)	196 (21.1)	177 (19.0)	61 (6.6)	46 (4.9)	34 (3.7)	19 (2.0)	937 [e]
Discussed the problem with a key person in my organization to whom I usually look for new information	183 (18.2)	224 (22.2)	232 (23.0)	184 (18.3)	90 (8.9)	48 (4.8)	32 (3.2)	12 (1.2)	2 (0.2)	1007 [f]
Intentionally searched library resources	111 (9.6)	217 (18.8)	204 (17.7)	211 (18.3)	178 (15.5)	130 (11.3)	56 (4.9)	34 (3.0)	11 (1.0)	1152 [g]
Asked a librarian in my organization	50 (8.2)	68 (11.2)	73 (12.0)	93 (15.3)	92 (15.2)	75 (12.4)	85 (14.0)	56 (9.2)	15 (0.7)	607 [h]
Searched a data base or had a data base searched	195 (21.7)	119 (13.3)	124 (13.8)	112 (12.5)	114 (12.7)	104 (11.6)	60 (6.7)	31 (3.5)	39 (4.3)	898 [i]
Asked a librarian outside my organization	21 (5.1)	34 (8.3)	34 (8.3)	44 (10.8)	34 (8.3)	52 (12.7)	37 (9.0)	73 (17.8)	80 (19.6)	409 [j]

[a]Note that 333 individuals skipped the entire question. [b]Note that 785 people did not mark this step. [c]Note that 1274 individuals did not mark this step. [d]Note that 1076 individuals did not mark this step. [e]Note that 531 individuals did not mark this step. [f]Note that 752 individuals did not mark this step. [g]Note that 676 individuals did not mark this step. [h]Note that 845 individuals did not mark this step. [i]Note that 349 individuals did not mark this step. [j]Note that 200 individuals did not mark this step.

Table D26. Order in Which Information Sources Were Used by Academically Affiliated Respondents to Complete Most Important Technical Project, Task, or Technical Problem

Source	Number (percentage) respondents using step -									Total respondents[a] (n = 341)
	1	2	3	4	5	6	7	8	9	
Used personal store of technical information	105 (41.8)	45 (17.9)	50 (19.9)	27 (10.0)	18 (4.8)	7 (2.8)	4 (1.6)	1 (0.4)	0	257 [b]
Discussed problem with a colleague in my organization	30 (15.2)	63 (32.0)	53 (26.9)	28 (14.2)	11 (5.6)	7 (3.6)	2 (1.0)	2 (1.0)	1 (0.5)	197 [c]
Discussed problem with my supervisor	18 (22.5)	9 (11.3)	15 (18.8)	9 (11.3)	9 (11.3)	4 (5.0)	3 (3.8)	2 (2.5)	11 (13.8)	80 [d]
Discussed problem with a colleague outside my organization	17 (12.6)	31 (23.0)	21 (15.6)	28 (20.7)	21 (15.6)	6 (4.4)	6 (4.4)	3 (2.2)	2 (1.5)	135 [e]
Discussed the problem with a key person in my organization to whom I usually look for new information	21 (19.4)	24 (22.2)	22 (20.4)	20 (18.5)	11 (10.2)	6 (5.6)	2 (1.9)	2 (1.9)	0	108 [f]
Intentionally searched library resources	37 (17.0)	59 (27.1)	57 (26.1)	32 (14.7)	15 (6.9)	12 (5.5)	2 (0.9)	4 (1.8)	0	218 [g]
Asked a librarian in my organization	10 (11.5)	13 (14.9)	17 (19.5)	17 (19.5)	11 (12.6)	6 (6.9)	10 (11.5)	2 (2.3)	1 (1.1)	87 [h]
Searched a data base or had a data base searched	46 (31.5)	27 (16.5)	13 (8.9)	13 (8.9)	24 (16.4)	7 (4.8)	6 (4.1)	4 (2.7)	6 (4.1)	146 [i]
Asked a librarian outside my organization	0 (0.0)	6 (13.3)	3 (6.7)	7 (15.6)	5 (11.1)	6 (13.3)	3 (6.7)	11 (24.4)	4 (8.9)	45 [j]

[a]Note that 56 individuals skipped the entire question. [b]Note that 34 people did not mark this step. [c]Note that 8 individuals did not mark this step. [d]Note that 205 individuals did not mark this step. [e]Note that 177 individuals did not mark this step. [f]Note that 150 individuals did not mark this step. [g]Note that 67 individuals did not mark this step. [h]Note that 198 individuals did not mark this step. [i]Note that 139 individuals did not mark this step. [j]Note that 240 individuals did not mark this step.

Table D27. Order in Which Information Sources Were Used by Government-Affiliated Respondents to Complete Most Important Technical Project, Task, or Technical Problem

Source	Number (percentage) respondents using step -									Total respondents[a] (n = 454)
	1	2	3	4	5	6	7	8	9	
Used personal store of technical information	120 (34.0)	62 (17.6)	69 (19.5)	44 (10.3)	30 (8.5)	15 (4.8)	8 (2.3)	1 (0.3)	4 (1.1)	353 [b]
Discussed problem with a colleague in my organization	66 (20.1)	104 (31.6)	69 (21.0)	47 (14.3)	24 (7.3)	10 (3.0)	5 (1.5)	3 (0.9)	1 (0.3)	329 [c]
Discussed problem with my supervisor	63 (27.9)	40 (17.7)	28 (12.4)	35 (15.5)	23 (10.2)	16 (7.1)	6 (2.7)	2 (0.9)	13 (5.8)	226 [d]
Discussed problem with a colleague outside my organization	24 (9.8)	39 (15.9)	39 (15.9)	54 (22.0)	47 (19.2)	10 (6.5)	11 (4.5)	11 (4.5)	4 (1.6)	239 [e]
Discussed the problem with a key person in my organization to whom I usually look for new information	39 (15.7)	58 (20.9)	65 (26.1)	47 (18.9)	20 (8.0)	12 (4.6)	9 (3.6)	4 (1.6)	1 (0.4)	249 [f]
Intentionally searched library resources	24 (8.9)	49 (18.1)	34 (12.5)	43 (15.9)	53 (19.6)	40 (14.8)	15 (5.5)	10 (3.7)	3 (1.1)	271 [g]
Asked a librarian in my organization	10 (6.7)	13 (8.7)	19 (12.8)	20 (13.4)	18 (12.1)	19 (12.8)	26 (17.4)	21 (14.1)	3 (2.0)	149 [h]
Searched a data base or had a data base searched	41 (19.2)	24 (11.2)	32 (15.0)	28 (13.1)	20 (9.3)	34 (15.9)	18 (8.4)	8 (3.7)	9 (4.2)	214 [i]
Asked a librarian outside my organization	3 (2.9)	5 (4.8)	10 (9.6)	6 (5.8)	9 (8.7)	10 (9.6)	9 (8.7)	24 (23.1)	28 (26.9)	104 [j]

[a]Note that 66 individuals skipped the entire question. [b]Note that 35 people did not mark this step. [c]Note that 59 individuals did not mark this step. [d]Note that 162 individuals did not mark this step. [e]Note that 143 individuals did not mark this step. [f]Note that 117 individuals did not mark this step. [g]Note that 117 individuals did not mark this step. [h]Note that 239 individuals did not mark this step. [i]Note that 174 individuals did not mark this step. [j]Note that 284 individuals did not mark this step.

Table D28. Order in Which Information Sources Were Used by Industry-Affiliated Respondents to Complete Most Important Technical Problem, Task, or Technical Problem

Source	Number (percentage) respondents using step -									Total respondents[a] (n = 1044)
	1	2	3	4	5	6	7	8	9	
Used personal store of technical information	314 (40.4)	147 (18.9)	139 (17.9)	90 (11.4)	46 (5.9)	21 (2.7)	13 (1.7)	2 (0.3)	5 (0.6)	777[b]
Discussed problem with a colleague in my organization	97 (13.4)	233 (32.1)	184 (25.3)	110 (15.2)	58 (8.0)	25 (3.4)	9 (1.2)	9 (1.2)	1 (0.1)	726[c]
Discussed problem with my supervisor	147 (30.9)	82 (17.2)	77 (16.2)	51 (10.7)	46 (9.7)	22 (4.6)	16 (3.4)	12 (2.5)	23 (4.8)	476[d]
Discussed problem with a colleague outside my organization	37 (7.6)	80 (16.5)	87 (17.9)	101 (20.8)	93 (19.1)	34 (7.0)	25 (5.1)	17 (3.5)	12 (2.5)	486[e]
Discussed the problem with a key person in my organization to whom I usually look for new information	117 (19.9)	130 (22.1)	132 (22.4)	105 (17.8)	52 (8.8)	29 (4.9)	17 (8.9)	6 (1.0)	1 (0.2)	589[f]
Intentionally searched library resources	46 (7.8)	91 (15.5)	96 (16.4)	121 (20.6)	101 (17.2)	71 (12.1)	37 (6.3)	18 (3.1)	5 (0.9)	586[g]
Asked a librarian in my organization	27 (8.2)	38 (11.5)	34 (10.3)	51 (15.4)	58 (17.5)	41 (12.4)	43 (13.0)	31 (9.4)	8 (2.4)	331[h]
Searched a data base or had a data base searched	96 (20.3)	60 (12.7)	66 (13.9)	64 (13.5)	63 (13.3)	60 (12.7)	32 (6.8)	13 (2.7)	20 (4.2)	474[i]
Asked a librarian outside my organization	15 (6.8)	17 (7.7)	18 (8.2)	27 (12.3)	18 (8.2)	31 (14.1)	20 (9.1)	30 (13.6)	44 (20.0)	220[j]

[a]Note that 148 individuals skipped the entire question. [b]Note that 119 people did not mark this step. [c]Note that 170 individuals did not mark this step. [d]Note that 420 individuals did not mark this step. [e]Note that 410 individuals did not mark this step. [f]Note that 307 individuals did not mark this step. [g]Note that 310 individuals did not mark this step. [h]Note that 565 individuals did not mark this step. [i]Note that 422 individuals did not mark this step. [j]Note that 676 individuals did not mark this step.

Table D29. Order in Which Information Sources Were Used by Engineers to Complete Most Important Technical Project, Task, or Technical Problem

Source	Number (percentage) respondents using step -									Total respondents[a] (n = 1627)
	1	2	3	4	5	6	7	8	9	
Used personal store of technical information	474 (39.1)	221 (18.2)	235 (19.4)	140 (11.6)	74 (6.1)	37 (3.1)	19 (1.6)	3 (0.2)	9 (0.7)	1212 [b]
Discussed problem with a colleague in my organization	178 (16.2)	363 (33.1)	255 (23.2)	159 (14.5)	82 (7.5)	33 (3.0)	13 (1.2)	11 (1.0)	4 (0.4)	1098 [c]
Discussed problem with my supervisor	215 (30.3)	115 (16.2)	108 (15.2)	88 (12.4)	69 (9.7)	37 (5.2)	22 (3.1)	16 (2.3)	39 (5.5)	709 [d]
Discussed problem with a colleague outside my organization	70 (9.1)	123 (16.0)	129 (16.8)	157 (20.4)	153 (19.9)	52 (6.8)	40 (5.2)	30 (3.9)	15 (2.0)	769 [e]
Discussed the problem with a key person in my organization to whom I usually look for new information	149 (17.8)	183 (21.8)	196 (23.4)	160 (19.1)	76 (9.1)	37 (4.4)	26 (3.1)	10 (1.2)	2 (0.2)	839 [f]
Intentionally searched library resources	84 (8.9)	173 (18.4)	160 (17.0)	175 (18.6)	149 (15.8)	110 (11.7)	51 (5.4)	30 (3.2)	10 (1.1)	942 [g]
Asked a librarian in my organization	38 (7.6)	61 (12.2)	62 (12.4)	77 (15.4)	67 (13.4)	65 (13.0)	68 (13.6)	49 (9.8)	12 (2.4)	499 [h]
Searched a data base or had a data base searched	158 (21.4)	95 (12.9)	101 (13.7)	94 (12.7)	92 (12.4)	88 (11.9)	51 (6.9)	28 (3.8)	32 (4.3)	739 [i]
Asked a librarian outside my organization	17 (5.1)	25 (7.4)	25 (7.4)	33 (9.8)	29 (8.6)	46 (13.7)	31 (9.2)	58 (17.3)	72 (21.4)	336 [j]

[a]Note that 245 individuals skipped the entire question. [b]Note that 170 people did not mark this step. [c]Note that 284 individuals did not mark this step. [d]Note that 673 individuals did not mark this step. [e]Note that 613 individuals did not mark this step. [f]Note that 543 individuals did not mark this step. [g]Note that 440 individuals did not mark this step. [h]Note that 933 individuals did not mark this step. [i]Note that 643 individuals did not mark this step. [j]Note that 1046 individuals did not mark this step.

Table D30. Order in Which Information Sources Were Used by Scientists to Complete Most Important Technical Project, Task, or Technical Problem

Source	Number (percentage) respondents using step -									Total respondents[a] (n = 235)
	1	2	3	4	5	6	7	8	9	
Used personal store of technical information	78 (43.3)	33 (18.3)	30 (16.7)	21 (11.7)	11 (6.1)	1 (0.6)	5 (2.8)	1 (0.6)	0	180[b]
Discussed problem with a colleague in my organization	20 (12.4)	54 (33.5)	40 (24.8)	23 (14.3)	11 (6.8)	8 (5.0)	3 (1.9)	2 (1.2)	0	161[c]
Discussed problem with my supervisor	21 (25.6)	15 (18.3)	11 (13.4)	8 (9.8)	10 (12.2)	6 (7.3)	2 (2.4)	1 (1.2)	8 (9.8)	82[d]
Discussed problem with a colleague outside my organization	8 (7.6)	20 (19.0)	21 (20.0)	25 (23.8)	14 (13.3)	8 (7.6)	3 (2.9)	3 (2.9)	3 (2.9)	105[e]
Discussed the problem with a key person in my organization to whom I usually look for new information	19 (17.9)	18 (17.0)	29 (27.4)	16 (15.1)	10 (9.4)	8 (7.5)	5 (4.7)	1 (0.9)	0	106[f]
Intentionally searched library resources	19 (13.0)	31 (21.2)	29 (19.9)	28 (19.2)	20 (13.7)	14 (9.6)	3 (2.1)	2 (1.4)	0	146[g]
Asked a librarian in my organization	8 (11.0)	5 (6.8)	4 (5.5)	10 (13.7)	20 (27.4)	8 (11.0)	10 (13.7)	6 (8.2)	2 (2.7)	73[h]
Searched a data base or had a data base searched	24 (22.0)	15 (13.8)	16 (14.7)	14 (12.8)	17 (15.6)	12 (11.0)	7 (6.4)	2 (1.8)	2 (1.8)	109[i]
Asked a librarian outside my organization	2 (4.1)	7 (14.3)	4 (8.2)	8 (16.3)	4 (8.2)	5 (10.2)	5 (10.2)	8 (16.3)	6 (12.2)	49[j]

[a]Note that 36 individuals skipped the entire question. [b]Note that 19 people did not mark this step. [c]Note that 38 individuals did not mark this step. [d]Note that 117 individuals did not mark this step. [e]Note that 94 individuals did not mark this step. [f]Note that 93 individuals did not mark this step. [g]Note that 53 individuals did not mark this step. [h]Note that 126 individuals did not mark this step. [i]Note that 90 individuals did not mark this step. [j]Note that 150 individuals did not mark this step.

Table D31. Order in Which Information Sources Were Used by Managers to Complete Most Important Technical Project, Task, or Technical Problem

Source	Number (percentage) respondents using step -									Total respondents[a] (n = 774)
	1	2	3	4	5	6	7	8	9	
Used personal store of technical information	197 (36.3)	93 (17.2)	105 (19.4)	64 (11.8)	45 (8.3)	17 (3.1)	14 (2.6)	3 (0.6)	4 (0.7)	542[b]
Discussed problem with a colleague in my organization	84 (16.4)	158 (30.9)	124 (24.2)	78 (15.2)	32 (6.3)	25 (4.9)	8 (1.6)	3 (0.6)	0	512[c]
Discussed problem with my supervisor	75 (24.4)	46 (15.0)	43 (14.0)	39 (12.7)	39 (12.7)	23 (7.5)	11 (3.6)	9 (2.9)	22 (7.2)	307[d]
Discussed problem with a colleague outside my organization	41 (9.9)	77 (18.6)	80 (19.4)	90 (21.8)	70 (16.9)	26 (6.3)	15 (3.6)	11 (2.7)	3 (0.7)	413[e]
Discussed the problem with a key person in my organization to whom I usually look for new information	97 (22.4)	102 (23.5)	88 (20.3)	79 (18.2)	37 (8.5)	16 (3.7)	11 (2.5)	2 (0.5)	2 (0.5)	434[f]
Intentionally searched library resources	27 (7.0)	47 (12.2)	68 (17.7)	73 (19.0)	69 (17.9)	47 (12.2)	31 (8.1)	18 (4.7)	5 (1.3)	385[g]
Asked a librarian in my organization	23 (10.2)	34 (15.1)	18 (8.0)	20 (8.9)	37 (16.4)	23 (10.2)	34 (15.1)	29 (12.9)	7 (3.1)	225[h]
Searched a data base or had a data base searched	73 (20.7)	52 (14.8)	45 (12.8)	47 (13.4)	38 (10.8)	53 (15.1)	28 (8.0)	4 (1.1)	12 (3.4)	352[i]
Asked a librarian outside my organization	11 (7.0)	13 (8.2)	14 (8.9)	13 (8.2)	13 (8.2)	17 (10.8)	12 (7.6)	34 (21.5)	31 (19.6)	158[j]

[a]Note that 132 individuals skipped the entire question. [b]Note that 109 people did not mark this step. [c]Note that 130 individuals did not mark this step. [d]Note that 335 individuals did not mark this step. [e]Note that 229 individuals did not mark this step. [f]Note that 208 individuals did not mark this step. [g]Note that 257 individuals did not mark this step. [h]Note that 417 individuals did not mark this step. [i]Note that 290 individuals did not mark this step. [j]Note that 484 individuals did not mark this step.

Table D32. Order in Which Information Sources Were Used by Nonmanagers to Complete Most Important Technical Project, Task, or Technical Problem

Source	Number (percentage) respondents using step -									Total respondents[a] (n = 1110)
	1	2	3	4	5	6	7	8	9	
Used personal store of technical information	354 (41.2)	166 (19.3)	158 (18.4)	98 (11.4)	42 (4.9)	24 (2.8)	10 (1.2)	2 (0.2)	5 (0.6)	859[b]
Discussed problem with a colleague in my organization	112 (14.7)	257 (33.8)	182 (23.9)	108 (14.2)	61 (8.0)	18 (2.4)	9 (1.2)	11 (1.4)	3 (0.4)	761[c]
Discussed problem with my supervisor	167 (34.2)	85 (17.4)	78 (16.0)	53 (10.9)	40 (8.2)	19 (3.9)	12 (2.5)	8 (1.6)	26 (5.3)	488[d]
Discussed problem with a colleague outside my organization	35 (7.4)	71 (15.1)	73 (15.5)	96 (20.4)	99 (21.1)	32 (6.8)	29 (6.2)	21 (4.5)	14 (3.0)	470[e]
Discussed the problem with a key person in my organization to whom I usually look for new information	80 (15.4)	108 (20.8)	130 (25.0)	97 (18.7)	48 (9.2)	29 (5.6)	19 (3.7)	8 (1.5)	0	519[f]
Intentionally searched library resources	80 (11.2)	157 (22.0)	124 (17.3)	132 (18.5)	104 (14.5)	76 (10.6)	22 (3.1)	16 (2.2)	4 (0.6)	715[g]
Asked a librarian in my organization	25 (7.2)	34 (9.8)	52 (14.9)	65 (18.7)	49 (14.1)	48 (13.8)	44 (12.6)	25 (7.2)	6 (1.7)	348[h]
Searched a data base or had a data base searched	112 (22.4)	57 (11.4)	73 (14.6)	61 (12.2)	69 (13.8)	49 (9.8)	31 (6.2)	23 (4.6)	25 (5.0)	500[i]
Asked a librarian outside my organization	7 (3.2)	17 (7.7)	17 (7.7)	28 (12.7)	19 (8.6)	31 (14.0)	24 (10.9)	34 (15.4)	44 (19.9)	221[j]

[a]Note that 143 individuals skipped the entire question. [b]Note that 89 people did not mark this step. [c]Note that 196 individuals did not mark this step. [d]Note that 469 individuals did not mark this step. [e]Note that 487 individuals did not mark this step. [f]Note that 438 individuals did not mark this step. [g]Note that 242 individuals did not mark this step. [h]Note that 609 individuals did not mark this step. [i]Note that 457 individuals did not mark this step. [j]Note that 736 individuals did not mark this step.

APPENDIX E
DESCRIPTIVE DATA ON SURVEY TOPICS 3 AND 4

INTRODUCTION

This study was funded as part of the NASA/DOD Aerospace Knowledge Diffusion Research Project. As scholarly inquiry, the project has both an immediate and a long-term purpose. In the first instance, it provides a practical and pragmatic basis for understanding how the results of federally funded research diffuse into the aerospace R&D process. Over the long term, it provides an empirical basis for understanding the aerospace knowledge diffusion process itself and its implications at the individual, organizational, national, and international levels. The project, for which five objectives were established, focuses on the channels used to communicate STI and on the aerospace STI social system.

BACKGROUND

Project objective 3 assumes that libraries and technical information centers and librarians play an important, but as yet undefined, role in the aerospace knowledge diffusion process and in the diffusion of federally funded aerospace STI. Figure 2 (page 16) presents a model that depicts the transfer of federally funded aerospace R&D vis-à-vis the U.S. government technical report. The model is composed of two parts: the **informal**, which relies on collegial contracts, and the **formal**, which relies on surrogates, information products, and information intermediaries to complete the transfer of knowledge form "producer" to "user." Project

objective 5 assumes that computer and information technology is an indispensable part of research process and is essential to the production, transfer, and use of knowledge. Recent advances in computer and information technology have had and will continue to have important effects on the following three aspects of research: data collection and analysis, communications and collaboration, and information storage and retrieval (National Academy of Sciences, National Academy of Engineering, Institute of Medicine, 1989).

The questionnaire used in *this* study contains questions pertinent to project objectives 3 and 5. These questions were included in *this* study to gather baseline data concerning library and technical information center use, importance, and interaction; to identify the attitudes of U.S. aerospace engineers and scientists toward and their use patterns of computer and information technology; and to validate questions that could be used in future studies concerning these topics. However, because these questions have no direct bearing on the research questions posed for *this* study, the responses are reported in this appendix and not in chapter 5.

PRESENTATION OF THE DATA

The survey instrument used in *this* study contains five questions concerning librarians and technical information centers and one question regarding the use of computer and information technology. The responses to these questions, which appear herein as survey topics 3 and 4, are presented in aggregate form and organizationally, according to academic, government, and industry affiliation.

Survey Topic 3: The Library and Technical Information Center

Survey participants were asked if a library or technical information center exists within their respective organizations (table E1). Overall, about 89 percent of the survey participants indicated that their organization has a library or technical information center. About 6 percent of the academically and government-affiliated respondents indicated the absence of a library or technical information center within their organization. About 14 percent of the industry-affiliated respondents indicated the absence of a library or technical information center within their organization.

Table E1. Existence of a Library or Technical Information Center

Library or technical information center	Number (percentage) having library or technical information center in -			Overall number (percentage) (n = 1839)
	Academia (n = 341)	Government (n = 454)	Industry (n = 1044)	
Yes	322 (94.4)	425 (93.6)	876 (85.8)	1643 (89.3)
No	19 (5.6)	29 (6.4)	148 (14.2)	196 (10.7)

Overall, survey participants visit a library or technical information center about 15 times in a 6-month period (table E2). Government-affiliated respondents make the fewest number of visits in a 6-month period (12.41), followed by industry-affiliated participants (13.36). Statistically, academics make significantly greater use of a library or technical information center. On the average, academically affiliated respondents visit a library or technical information center about 24 times in a 6-month period.

Table E2. Use of a Library or Technical Information Center

[Total respondents, 1703[a]]

Source	Mean number of visits to a library or technical information center in a 6-month period
Overall	15.12
Academia	24.16
Industry	13.36
Government	12.41

[a]Note that 136 individuals did not answer this question but should have.

Survey participants were asked to rate the importance of a library or technical information center in terms of performing their present professional duties (table E3). Overall, a library or technical information center is rated about a 3.9

Table E3. Importance of a Library or Technical Information Center

[Total respondents, 1792[a]]

Source	Average[b] (mean) rating importance in -
Overall	3.87
Academia	4.46
Industry	3.67
Government	3.88

[a]Note that 47 individuals did not answer this question but should have. [b]A 1 to 5 point scale was used to measure importance, with "1" being the lowest possible importance and "5" being the highest possible importance. Hence, the higher the average (mean), the greater the importance.

by survey participants in terms of its importance in performing their present professional duties. Statistically, a library or technical information center is

significantly more important ($\bar{X}$=4.46) to academics than to other respondents in terms of performing their present professional duties. A library or technical information center is least important ($\bar{X}$=3.67) to industry-affiliated respondents in terms of performing their present professional duties.

The type or kind of interaction between a library and technical information center and U.S. aerospace engineers and scientists was explored. Survey participants were asked to indicate the extent of their interaction with a library or technical information center in a 6-month period (table E4). The intent was to explore the

Table E4. Extent of Library or Technical Information Center Interaction

Type of interaction	Average (mean) number of interactions in 6-month period in -			Overall average (mean) number of interactions	Total respondents (n = 1839)
	Academia (n = 341)	Government (n = 454)	Industry (n = 1044)		
Requested help during visit	4.74	3.66	6.21	5.29	1593[a]
Received offer of help during visit	3.65	4.50	5.68	5.01	1494[b]
Requested something in writing or electronically	6.14	4.39	4.74	4.90	1542[c]
Requested something by telephone	2.24	3.10	3.03	2.90	1493[d]
Requested something through a proxy	2.11	2.14	2.10	2.11	1386[e]

[a]Note that 246 individuals did not answer this question but should have. [b]Note that 345 individuals did not answer this question but should have. [c]Note that 297 individuals did not answer this question but should have. [d]Note that 346 individuals did not answer this question but should have. [e]Note that 453 individuals did not answer this question but should have.

interface between the formal and informal components of the model depicted in figure 2. Overall means of 5.29 and 5.01 interactions, respectively, are recorded for "requested the help of a librarian or technical information specialist during their

visit" and "received an offer of help from a librarian or technical information specialists during their visit." To the extent that visits and interactions constitute a valid comparison, an interaction initiated by either the information intermediary or the user occurs about two-thirds of the time.

To further explore the type or kind of interaction between a library and technical information center and U.S. aerospace engineers and scientists, survey participants were asked to indicate the number of times they request something in writing or electronically, by telephone, or through a proxy. An overall mean of 4.90 interactions is recorded for "requested something in writing or electronically from a library or technical information center," followed by overall means of 2.90 and 2.11, respectively, for "requested something by telephone" and "requested something through a proxy."

Organizationally, a mean of 6.21 interactions for "requested the help of a librarian or technical information specialist during their visit" is recorded for industry-affiliated respondents. A mean of 6.14 interactions for "requested something in writing or electronically from a library or technical information center" is recorded for academics. A mean of 4.50 interactions for "received an offer of help from a librarian or technical information specialists during their visit" is recorded for government-affiliated participants.

Overall, about 93 percent of the survey participants use a library or technical information center in a 6-month period. Survey respondents were asked to indicate their reasons for not using a library or technical information center (table E5).

Table E5. Reasons for Library or Technical Information Center Nonuse

Reasons for nonuse	Number (percent) who specified a reason for nonuse in -			Overall number (percentage) specifying reason[a]
	Academia (n = 341)	Government (n = 454)	Industry (n = 1044)	
No information needs	11 (29.7) (n = 37)	11 (58.4) (n = 21)	33 (47.1) (n = 70)	55 (43.0)
Information needs met some other way	31 (70.5) (n = 44)	24 (100.0) (n = 24)	67 (89.3) (n = 75)	122 (85.3)
Library unable to help in previous attempts	5 (13.5) (n = 37)	1 (5.0) (n = 20)	9 (14.5) (n = 62)	15 (12.6)
Library physically too far away	8 (15.4) (n = 39)	7 (33.3) (n = 21)	24 (36.9) (n = 65)	39 (29.6)
Library staff not cooperative or helpful	12 (5.3) (n = 38)	2 (10.0) (n = 20)	5 (8.2) (n = 61)	19 (7.6)
Library staff does not understand individual's information needs	5 (13.2) (n = 38)	3 (15.0) (n = 20)	8 (13.1) (n = 61)	16 (13.4)
Library does not have information individual needs	11 (28.2) (n = 39)	7 (35.0) (n = 20)	20 (33.3) (n = 60)	38 (31.9)
No need for library; individual has own personal library	17 (41.5) (n = 41)	9 (45.0) (n = 20)	22 (35.5) (n = 62)	48 (39.0)
Library too slow in getting needed information	11 (28.9) (n = 41)	3 (15.0) (n = 20)	11 (18.3) (n = 60)	25 (21.2)
Required to pay to use library	4 (10.5) (n = 38)	1 (5.0) (n = 20)	2 (3.3) (n = 61)	7 (5.0)
Discouraged from using library	0 (0.0) (n = 38)	0 (0.0) (n = 20)	2 (3.3) (n = 61)	2 (1.7)

[a]Note that 1711 individuals either visited or requested information and therefore did not answer the question.

Only about 7 percent of the respondents d0 not use a library or technical information center in a 6-month period. Data contained in table E5 were used to construct the following list of the five most frequently cited reasons for library and technical information center nonuse.

Reasons for Library and Technical Information Center Nonuse by Survey Respondents

Reason	**Percentage (Number of Respondents) Specifying Reason for Nonuse**
Information needs met some other way	85.3 (122)
No information needs	43.0 (55)
No need for library; individual has own personal library	39.0 (48)
Library does not have information individual needs	31.9 (38)
Library physically too far away	29.6 (39)

For the most part, the reasons for nonuse are largely "user" centered rather than "library" centered. With the exception of "library does not have the information the individual needs" (31.9 percent; 38 respondents) and "library phyically too far away" (29.6 percent; 39 respondents), library-centered reasons such as "library too slow..." (21.2 percent; 25 respondents), "library staff does not understand information needs" (13.4 percent; 16 respondents), and "library unable to help in previous attempts" (12.6 percent; 15 respondents) are infrequently cited as reasons for nonuse. Only 5.0 percent of the nonusers (7 respondents) indicated that they are required to pay for using a library or technical information center. Less than 2.0 percent (2 respondents) indicated that they are discouraged from using the library.

Survey Topic 4: Computer and Information Technology

The use of 15 computer and information technologies by U.S. aerospace engineers and scientists was investigated. Survey participants were asked to determine their use, potential use, and nonuse of selected computer and information technologies in terms of preforming their present professional duties (table E6.)

Table E6. Overall Use of Computer and Information Technology

Information technology	Number (percentage) responding -			Total respondents (n = 1839)
	I already use it	I don't use it, but may in the future	I don't use it, and doubt I will	
Audiotapes and cassettes	659 (37.3)	574 (32.5)	535 (30.3)	1768[a]
Motion picture film	513 (29.0)	530 (30.0)	726 (41.0)	1769[b]
Videotape	1094 (61.4)	494 (27.7)	193 (10.8)	1781[c]
Desktop-electronic publishing	974 (55.1)	614 (34.7)	180 (10.2)	1768[d]
Floppy disks	1494 (83.5)	221 (12.3)	75 (4.2)	1790[e]
Computer cassette-cartridge tapes	707 (40.3)	603 (34.4)	443 (25.3)	1753[f]
Electronic mail	968 (54.4)	659 (37.0)	154 (8.6)	1781[g]
Electronic bulletin boards	530 (30.1)	896 (50.9)	334 (19.0)	1760[h]
Fax or telex	1606 (89.4)	153 (8.5)	37 (2.1)	1796[i]
Electronic data bases	1025 (57.2)	650 (36.3)	116 (6.5)	1791[j]
Videoconferencing	369 (21.0)	938 (53.3)	452 (25.7)	1759[k]
Teleconferencing	991 (51.2)	595 (33.4)	274 (15.4)	1780[l]
Micrographics and microforms	1145 (64.3)	356 (20.2)	280 (15.7)	1781[m]
Laser disk, videodisk, or CD-ROM	135 (7.8)	1130 (65.1)	472 (27.2)	1737[n]
Electronic networks	782 (44.4)	773 (43.9)	207 (11.7)	1762[o]

[a]Note that 71 individuals did not answer this question but should have. [b]Note that 70 individuals did not answer this question but should have. [c]Note that 58 individuals did not answer this question but should have. [d]Note that 71 individuals did not answer this question but should have. [e]Note that 49 individuals did not answer this question but should have. [f]Note that 86 individuals did not answer this question but should have. [g]Note that 58 individuals did not answer this question but should have. [h]Note that 79 individuals did not answer this question but should have. [i]Note that 43 individuals did not answer this question but should have. [j]Note that 48 individuals did not answer this question but should have. [k]Note that 179 individuals did not answer this question but should have. [l]Note that 59 individuals did not answer this question but should have. [m]Note that 58 individuals did not answer this question but should have. [n]Note that 102 individuals did not answer this question but should have. [o]Note that 77 individuals did not answer this question but should have.

As shown in table E6, survey respondents use a variety of computer and information technologies. The percentage of "I already use it" responses ranged from a high of 89.4 percent (fax or telex) to a low of 7.8 percent (laser disk, video-disk, or CD-ROM). The five most frequently used computer and information technologies for survey respondents, in descending order of use, follow.

Computer and Information Technology Used Most Frequently by Survey Respondents

Technology	Percentage Using
Fax or telex	89.4
Floppy disks	83.5
Micrographics and microforms	64.3
Videotape	61.4
Electronic data bases	57.2

A further look at table E6 reveals several computer and information technologies for which a considerable number of "I don't use it, but may in the future" responses are recorded. These responses range from a high of 65.1 percent (laser disk, videodisk, or CD-ROM) to a low of 8.5 percent (fax or telex). The five computer and information technologies receiving the highest percentage of the "I don't use it, but may in the future" responses a·pear, in descending order of possible future use, on the next page.

Computer and Information Technology Which May Be Used in the Future by Survey Respondents

Technology	Percentage Indicating Possible Future Use
Laser disk, videodisk, or CD-ROM	65.1
Videoconferencing	53.3
Electronic bulletin boards	50.9
Electronic networks	43.9
Electronic mail	37.0

Table E6 also reveals the computer and information technologies for which survey participants indicate "I don't use it, and doubt if I will" responses. The percentages of these responses range from a high of 41.0 percent (motion picture film) to a low of 2.1 percent (fax or telex). The five computer and information technologies receiving the highest percentage of the "I don't use it, and doubt I will" responses appear below in descending order of nonuse and unlikely use.

Computer and Information Technology Not Used and Unlikely To Be Used in the Future by Survey Respondents

Technology	Percentage Indicating Nonuse and Unlikely Use
Motion picture film	41.0
Audiotapes and cassettes	30.3
Laser disk, videodisk, or CD-ROM	27.2
Videoconferencing	25.7
Computer cassette-cartridge tapes	25.3

Table E7. Use of Computer and Information Technology in Academia

Information technology	Number (percentage) responding - I already use it	I don't use it, but may in the future	I don't use it, and doubt I will	Total respondents (n = 341)
Audiotapes and cassettes	137 (41.9)	103 (31.5)	87 (26.6)	327 [a]
Motion picture film	128 (38.9)	102 (31.0)	128 (30.1)	329 [b]
Videotape	192 (58.5)	104 (31.7)	32 (9.8)	328 [c]
Desktop-electronic publishing	190 (57.9)	110 (33.5)	28 (8.5)	328 [d]
Floppy disks	285 (86.6)	37 (11.2)	7 (2.1)	329 [e]
Computer cassette-cartridge tapes	140 (43.3)	113 (35.0)	70 (21.7)	323 [f]
Electronic mail	184 (55.9)	122 (37.1)	23 (7.0)	329 [g]
Electronic bulletin boards	81 (24.8)	180 (55.0)	66 (20.2)	327 [h]
Fax or telex	279 (84.5)	43 (13.0)	8 (2.4)	330 [i]
Electronic data bases	185 (55.9)	130 (39.3)	16 (4.8)	331 [j]
Videoconferencing	30 (32.6)	178 (43.6)	116 (23.8)	324 [k]
Teleconferencing	107 (9.3)	143 (54.9)	78 (35.8)	328 [l]
Micrographics and microforms	226 (69.1)	61 (18.7)	40 (12.2)	327 [m]
Laser disk, videodisk, or CD-ROM	35 (10.1)	219 (67.8)	69 (21.4)	323 [n]
Electronic networks	145 (44.2)	153 (46.6)	30 (9.1)	328 [o]

[a]Note that 14 individuals did not answer this question but should have. [b]Note that 12 individuals did not answer this question but should have. [c]Note that 13 individuals did not answer this question but should have. [d]Note that 13 individuals did not answer this question but should have. [e]Note that 12 individuals did not answer this question but should have. [f]Note that 18 individuals did not answer this question but should have. [g]Note that 12 individuals did not answer this question but should have. [h]Note that 14 individuals did not answer this question but should have. [i]Note that 11 individuals did not answer this question but should have. [j]Note that 10 individuals did not answer this question but should have. [k]Note that 17 individuals did not answer this question but should have. [l]Note that 13 individuals did not answer this question but should have. [m]Note that 14 individuals did not answer this question but should have. [n]Note that 18 individuals did not answer this question but should have. [o]Note that 13 individuals did not answer this question but should have.

As shown in table E7, academically affiliated respondents use a variety of computer and information technologies. The percentage of "I already use it" responses range from a high of 86.6 percent (floppy disks) to a low of 9.3 percent (teleconferencing). The five most frequently used computer and information technologies for academically affiliated respondents, in descending order of use, follow.

Computer and Information Technology Used Most Frequently by Academically Affiliated Respondents

Technology	Percentage Using
Floppy disks	86.6
Fax or telex	84.5
Micrographics and microforms	69.1
Videotape	58.5
Desktop-electronic publishing	57.9

A further look at table E7 reveals several computer and information technologies for which a considerable number of "I don't use it, but may in the future" responses are recorded. These responses range from a high of 67.8 percent (laser disk, videodisk, or CD-ROM) to a low of 11.2 percent (floppy disks). The five computer and information technologies receiving the highest percentage of "I don't use it, but may in the future" responses from academically affiliated respondents, in descending order of possible future use, appear below.

Computer and Information Technology Which May Be Used in the Future by Academically Affiliated Respondents

Technology	Percentage Indicating Possible Future Use
Laser disk, videodisk, or CD-ROM	67.8
Electronic bulletin boards	55.0
Teleconferencing	54.9
Electronic networks	46.6
Videoconferencing	43.6

Table E7 also reveals the computer and information technologies for which academically affiliated participants indicate "I don't use it, and doubt I will" responses. The percentages of these responses range from a high of 35.8 percent (teleconferencing) to a low of 2.1 percent (floppy disks). The five computer and information technologies receiving the highest percentage of the "I don't use it, and doubt I will" responses appear below in descending order of nonuse and unlikely use.

Computer and Information Technology Not Used and Unlikely To Be Used in the Future by Academically Affiliated Respondents

Technology	Percentage Indicating Nonuse and Unlikely Use
Teleconferencing	35.8
Motion picture film	30.1
Audiotapes and cassettes	26.6
Videoconferencing	23.8
Computer cassette-cartridge tapes	21.7

Table E8. Use of Computer and Information Technology in Government

Information technology	Number (percentage) responding - I already use it	I don't use it, but may in the future	I don't use it, and doubt I will	Total respondents (n = 454)
Audiotapes and cassettes	156 (35.5)	152 (34.5)	132 (30.0)	440 [a]
Motion picture film	136 (30.9)	138 (31.4)	166 (37.7)	440 [b]
Videotape	284 (64.1)	116 (26.2)	43 (9.7)	443 [c]
Desktop-electronic publishing	260 (59.2)	139 (31.7)	40 (9.1)	449 [d]
Floppy disks	386 (87.1)	44 (9.9)	13 (2.9)	443 [e]
Computer cassette-cartridge tapes	162 (37.1)	159 (36.4)	116 (26.5)	437 [f]
Electronic mail	289 (64.8)	124 (27.8)	33 (7.4)	446 [g]
Electronic bulletin boards	177 (40.3)	197 (44.9)	65 (14.8)	439 [h]
Fax or telex	390 (87.4)	48 (10.8)	8 (1.8)	446 [i]
Electronic data bases	281 (63.3)	128 (28.8)	35 (7.9)	444 [j]
Videoconferencing	113 (54.1)	242 (32.7)	82 (13.3)	437 [k]
Teleconferencing	240 (25.9)	145 (55.4)	59 (18.8)	444 [l]
Micrographics and microforms	282 (63.5)	95 (21.4)	67 (15.1)	444 [m]
Laser disk, videodisk, or CD-ROM	39 (9.0)	289 (66.6)	106 (24.4)	434 [n]
Electronic networks	230 (2.0)	167 (37.8)	45 (10.2)	442 [o]

[a]Note that 14 individuals did not answer this question but should have. [b]Note that 14 individuals did not answer this question but should have. [c]Note that 11 individuals did not answer this question but should have. [d]Note that 5 individuals did not answer this question but should have. [e]Note that 11 individuals did not answer this question but should have. [f]Note that 17 individuals did not answer this question but should have. [g]Note that 8 individuals did not answer this question but should have. [h]Note that 15 individuals did not answer this question but should have. [i]Note that 8 individuals did not answer this question but should have. [j]Note that 10 individuals did not answer this question but should have. [k]Note that 17 individuals did not answer this question but should have. [l]Note that 10 individuals did not answer this question but should have. [m]Note that 10 individuals did not answer this question but should have. [n]Note that 20 individuals did not answer this question but should have. [o]Note that 12 individuals did not answer this question but should have.

As shown in table E8, government-affiliated respondents use a variety of computer and information technologies. The percentage of "I already use it" responses range from a high of 87.4 percent (fax or telex) to a low of 2.0 percent (electronic networks). The five most frequently used computer and information technologies for government-affiliated respondents appear, in descending order of use, on the next page.

Computer and Information Technology Used Most Frequently by Government-Affiliated Respondents

Technology	Percentage Using
Fax or telex	87.4
Floppy disks	87.1
Electronic mail	64.8
Videotape	64.1
Micrographics and microforms	63.5

A further look at table E8 reveals several computer and information technologies for which a considerable number of "I don't use it, but may in the future" responses are recorded. The percentages of these responses range from a high of 66.6 percent (laser disk, videodisk, or CD-ROM) to a low of 9.9 percent (floppy disks). The five computer and information technologies receiving the highest percentage of "I don't use it, but may in the future" responses from government-affiliated respondents appear below in descending order of possible future use.

Computer and Information Technology Which May Be Used in the Future by Government-Affiliated Respondents

Technology	Percentage Indicating Possible Future Use
Laser disk, videodisk, or CD-ROM	66.6
Teleconferencing	55.4
Electronic bulletin boards	44.9
Electronic networks	37.8
Computer cassette-cartridge tapes	36.4

Table E8 also reveals the computer and information technologies for which government-affiliated participants indicate "I don't use it, and doubt if I will" responses. The percentages of these responses range from a high of 37.7 percent (motion picture film) to a low of 1.8 percent (fax or telex). The five computer and information technologies receiving the highest percentage of the "I don't use it, and doubt I will" responses from government-affiliated responses appear below in descending order of nonuse and unlikely use.

Computer and Information Technology Not Used and Unlikely To Be Used in the Future by Government-Affiliated Respondents

Technology	Percentage Indicating Nonuse and Unlikely Use
Motion picture film	37.7
Audiotapes and cassettes	30.0
Computer cassette-cartridge tapes	26.5
Laser disk, videodisk, or CD-ROM	24.4
Teleconferencing	18.8

As shown in table E9, industry-affiliated respondents use a variety of computer and information technologies. The percentage of "I already use it" responses range from a high of 91.9 percent (fax or telex) to a low of 6.2 percent (laser disk, videodisk, or CD-ROM). The five most frequently used computer and information technologies for industry-affiliated respondents appear, in descending order of use, on the next page.

Table E9. Use of Computer and Information Technology in Industry

Information technology	Number (percentage) responding - I already use it	I don't use it, but may in the future	I don't use it, and doubt I will	Total respondents (n = 1044)
Audiotapes and cassettes	366 (36.6)	319 (31.9)	316 (31.9)	1001 [a]
Motion picture film	249 (24.9)	290 (29.0)	461 (46.1)	1000 [b]
Videotape	618 (61.2)	274 (27.1)	118 (11.7)	1010 [c]
Desktop-electronic publishing	524 (52.3)	365 (36.5)	112 (11.2)	1001 [d]
Floppy disks	823 (80.8)	140 (13.8)	55 (5.4)	1018 [e]
Computer cassette-cartridge tapes	405 (40.8)	331 (33.3)	257 (25.9)	993 [f]
Electronic mail	495 (49.2)	413 (41.1)	98 (9.7)	1006 [g]
Electronic bulletin boards	272 (27.4)	519 (52.2)	203 (20.4)	994 [h]
Fax or telex	937 (91.9)	62 (6.1)	21 (2.0)	1020 [i]
Electronic data bases	559 (55.0)	392 (38.6)	65 (6.4)	1016 [j]
Videoconferencing	226 (56.0)	518 (30.5)	254 (13.6)	998 [k]
Teleconferencing	564 (22.6)	307 (51.9)	137 (25.5)	1008 [l]
Micrographics and microforms	637 (63.1)	200 (19.8)	173 (17.1)	1010 [m]
Laser disk, videodisk, or CD-ROM	61 (6.2)	622 (63.5)	297 (30.3)	980 [n]
Electronic networks	407 (41.0)	453 (45.7)	132 (13.3)	992 [o]

[a]Note that 43 individuals did not answer this question but should have. [b]Note that 44 individuals did not answer this question but should have. [c]Note that 34 individuals did not answer this question but should have. [d]Note that 43 individuals did not answer this question but should have. [e]Note that 26 individuals did not answer this question but should have. [f]Note that 51 individuals did not answer this question but should have. [g]Note that 38 individuals did not answer this question but should have. [h]Note that 50 individuals did not answer this question but should have. [i]Note that 24 individuals did not answer this question but should have. [j]Note that 28 individuals did not answer this question but should have. [k]Note that 46 individuals did not answer this question but should have. [l]Note that 36 individuals did not answer this question but should have. [m]Note that 34 individuals did not answer this question but should have. [n]Note that 64 individuals did not answer this question but should have. [o]Note that 52 individuals did not answer this question but should have.

Computer and Information Technology Used Most Frequently by Industry-Affiliated Respondents

Technology	**Percentage Using**
Fax or telex	91.9
Floppy disks	80.8
Micrographics and microforms	63.1
Videotape	61.2
Videoconferencing	56.0

A further look at table E9 reveals several computer and information technologies for which a considerable number of "I don't use it, but may in the future" responses are recorded. The percentages of these responses range from a high of 63.5 percent (laser disk, videodisk, or CD-ROM) to a low of 6.1 percent (fax or telex). The five computer and information technologies receiving the highest percentage of "I don't use, but may in the future" responses from industry-affiliated respondents appear below in descending order of possible future use.

Computer and Information Technology Which May Be Used in the Future by Industry-Affiliated Respondents

Technology	**Percentage Indicating Possible Future Use**
Laser disk, videodisk, or CD-ROM	63.5
Electronic bulletin boards	52.2
Teleconferencing	51.9
Electronic networks	45.7
Electronic data bases	38.6

Table E9 also reveals the computer and information technologies for which industry-affiliated participants indicated "I don't use it, and doubt if I will" responses. The percentages of these responses range from a high of 46.1 percent (motion picture film) to a low of 2.0 percent (fax or telex). The five computer and information technologies receiving the highest percentage of the "I don't use it, and doubt I will" responses from industry-affiliated respondents appear, in descending order of nonuse and unlikely use, on the next page.

Computer and Information Technology Not Used and Unlikely To Be Used by Industry-Affiliated Respondents

Technology	Percentage Indicating Nonuse and Unlikely Use
Motion picture film	46.1
Audiotapes and cassettes	31.9
Laser disk, videodisk, or CD-ROM	30.3
Computer cassette-cartridge tapes	25.9
Teleconferencing	25.5

For purposes of data analysis, the 15 computer and information technologies are grouped into the following 3 categories: mature, maturing, and nascent. The titles are contrived to provide a label for identification only. The placement of the computer and information technologies within the three categories is, for the most part, arbitrary. The intent is to establish a context in which "use" by U.S. aerospace engineers and scientists might be viewed and discussed.

Mature	Maturing	Nascent
Audiotapes and cassettes	Laser disk, videodisk, or CD-ROM	Electronic networks
Motion picture film	Teleconferencing	Electronic mail
Videotape	Videoconferencing	
Fax or telex	Electronic data bases	
Computer cassettes-cartridge tapes	Desktop-electronic publishing	
Micrographics and microforms		
Floppy disks		

The aggregrate responses of the survey respondents are compiled for the three categories. Responses for each caregory are displayed in terms of use, possible future use, nonuse, and unlikely use.

Use of Mature Computer and Information Technologies by Survey Respondents

Technology	Percentage Using	Percentage Indicating Possible Future Use	Percentage Indicating Nonuse and Unlikely Use
Audiotapes and cassettes	37.3	32.5	30.3
Motion picture film	29.0	30.0	41.0
Videotape	61.4	27.7	10.8
Fax or telex	89.4	8.5	2.1
Computer cassettes-cartridge tapes	40.3	34.4	25.3
Micrographics and microforms	64.3	20.2	15.7
Floppy disks	83.5	12.3	4.2

Overall, survey respondents are using the mature computer and information technologies. Respondents are about evenly divided on their use, possible future use, and nonuse and unlikely use of the more mature computer and information technologies such as audiotapes and cassettes, motion picture film, and computer cassettes-cartridge tapes. Fax or telex (89.4 percent), floppy disks (83.5 percent), and micrographics and microforms (64.3 percent) enjoy the highest current use and the lowest possible future use, nonuse, and unlikely use.

Use of Maturing Computer and Information Technologies by Survey Respondents

Technology	Percentage Using	Percentage Indicating Possible Future Use	Percentage Indicating Nonuse and Unlikely Use
Laser disk, videodisk, or CD-ROM	7.8	65.1	27.2
Teleconferencing	51.2	33.4	15.4
Videoconferencing	21.0	53.3	25.7
Electronic data bases	57.2	36.3	6.5
Desktop-electronic publishing	55.1	34.7	10.2

Over 50 percent of the survey respondents are using electronic data bases (57.2 percent), teleconferencing (51.2 percent), and desktop-electronic publishing (55.1 percent). The percentages indicating possible future are highest for laser disk, videodisk, or CD-ROM and videoconferencing. The percentages indicating nonuse and unlikely use for the maturing computer and information technologies are relatively low.

Use of Nascent Computer and Information Technologies by Survey Respondents

Technology	Percentage Using	Percentage Indicating Possible Future Use	Percentage Indicating Nonuse and Unlikely Use
Electronic networks	44.4	43.9	11.7
Electronic mail	54.4	37.0	8.6

About 88 percent of the survey participants are either using or will possibly use electronic networks in the future and about 91 percent are either using or will possibly use electronic mail in the future. Nonuse and unlikely use is very low.

DISCUSSION OF THE FINDINGS

The process by which U.S. aerospace engineers and scientists obtain the information they use to complete projects and tasks and solve technical problems affects their use of libraries and technical information centers. The results of the several engineering information use studies reviewed in chapter 3 and the results of *this* study reported in chapter 5 support this position. The process also illustrates the interface between the two parts of the model found in figure 2.

Engineers appear to assume personal responsibility for meeting their information needs. They apparently prefer a personalized and informal approach to obtaining information. Previous research does not indicate that this finding varies from one engineering discipline to another. Only after they have exhausted their personal store of information and have consulted with their colleagues do they turn to formal information sources such as libraries and technical information centers. In doing so, U.S. aerospace engineers and scientists tend to assume personal responsibility for fulfilling their information needs by trying to find the information themselves before soliciting the help of a librarian or technical information specialist.

The findings permit the formulation of the following general statements regarding libraries and technical information centers:

1. Libraries and technical information centers are used and are important to U.S. aerospace engineers and scientists.

2. Overall ($\bar{X}$=3.8655), U.S. aerospace engineers and scientists in academia rate the importance of libraries and technical information centers higher ($\bar{X}$=4.4559) than do their counterparts in government ($\bar{X}$=3.8814) and industry ($\bar{X}$=3.6673). Overall ($\bar{X}$=15.1180), U.S. aerospace engineers and scientists in academia visit a library or technical information center more times ($\bar{X}$=24.1619) in a 6-month period than do their counterparts in government ($\bar{X}$=12.4089) and industry ($\bar{X}$=13.3583).

3. Library and technical information center nonuse appears to have more to do with the process by which U.S. aerospace engineers and scientists obtain information.

Finally, readers should note that the original plan was to compare data regarding the "number of visits to a library in a 6-month period" with "distance." The intent was to test the hypothesis that library use decreases as a function of distance. Unfortunately, the questions were improperly phrased. Number of visits was keyed to "your library" and distance was keyed to "a library."

Computer and information technology continues to have a significant and widespread impact on the conduct of research in terms of data collection and analysis, communication and collaboration among researchers, and information storage and retrieval. Overall, Shuchman (1981) found that computer and information technology has "high" potential usefulness but relatively low use among engineers. Shuchman reported that, among the six engineering disciplines studied, aeronautical engineers were heavy users of existing computer and information technology and showed high potential for using the new and emerging computer and information technologies. The results of the pilot study (Pinelli, et al., 1989) confirm this finding.

The findings permit the formulation of the following general statements regarding computer and information technology:

1. The relatively high use and potential use of computer and information technology by U.S. aeronautical engineers and scientists reported by Shuchman (1981) and the pilot study (Pinelli, et at., 1989) was also found in this study.

2. Although the exact purpose was not determined by this study, overall and organizationally U.S. aerospace engineers and scientists make considerable use of computer and information technology.

3. U.S. aerospace engineers and scientists are using the mature computer and information technology. They are also using and indicate potential use of the the maturing computer and information technology, and they are likely to use the nascent computer and information technology.

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16. Abstract
A study was undertaken that investigated the relationship between the use of U.S. government technical reports by U.S. aerospace engineers and scientists and selected institutional and sociometric variables. Survey research is the methodology used for the study. Data were collected by means of a self-administered mail questionnaire. The approximately 34 000 members of the American Institute of Aeronautics and Astronautics (AIAA) served as the study population. The response rate for the survey was 70 percent. A dependent relationship was found to exist between the use of U.S. government technical reports and three of the institutional variables (academic preparation, years of professional aerospace work experience, and technical discipline). The use of U.S. government technical reports was found to be independent of all of the sociometric variables. The institutional variables best explain the use of U.S. government technical reports by U.S. aerospace engineers and scientists.

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